

AERO DIGEST

AVIATION ENGINEERING

NOVEMBER 1955

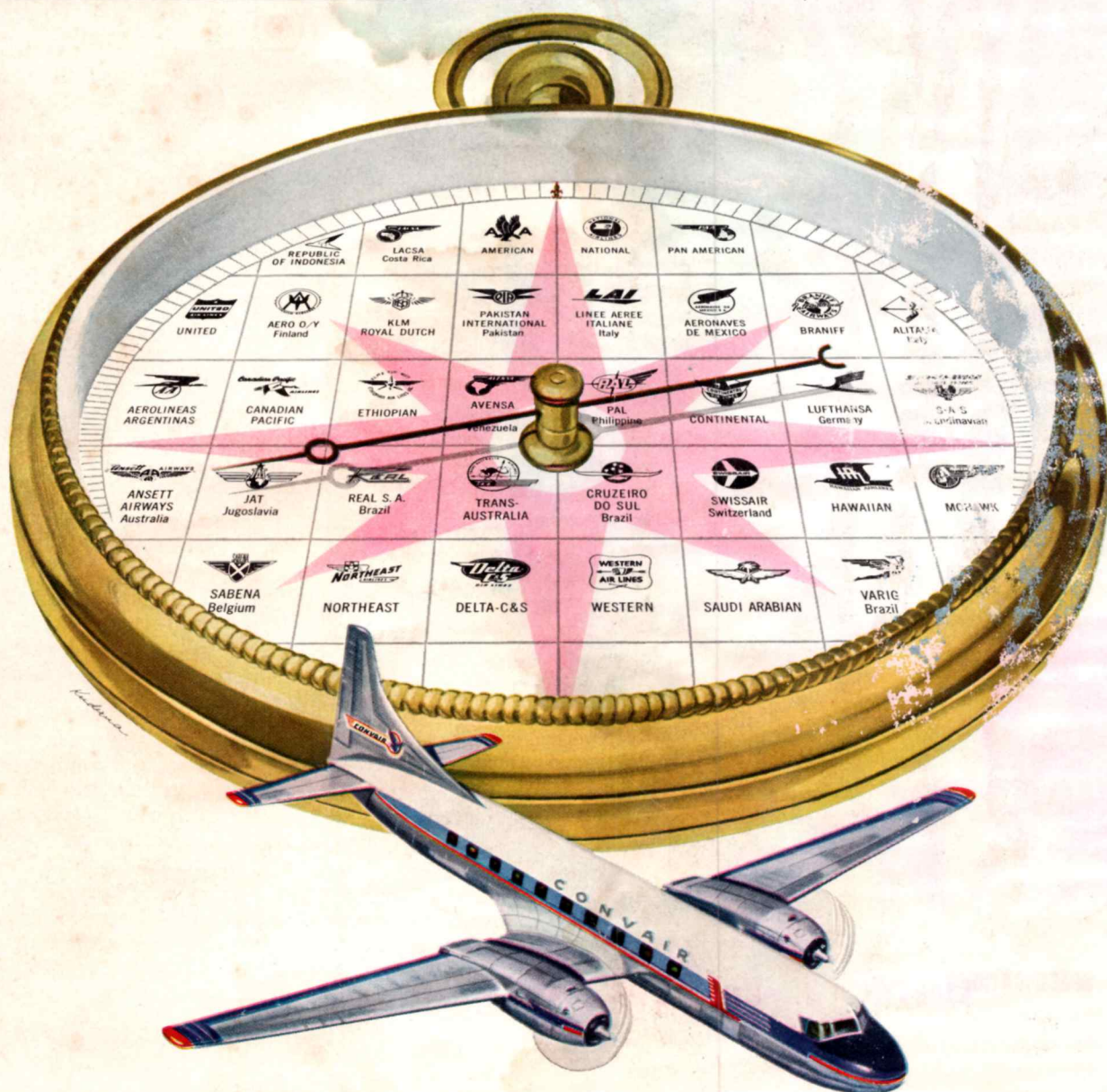
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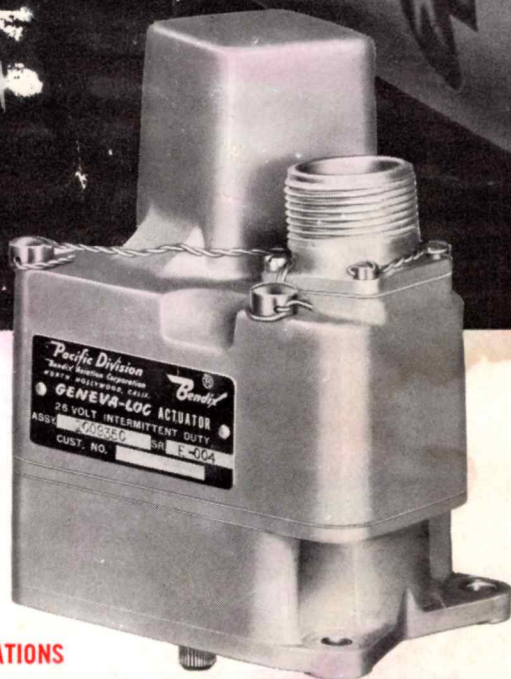


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VISIBILITY by Swedlow

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Developed for the USAF and now in production by McDonnell Aircraft Corporation, the F-101A Voodoo lives up to its name by an almost supernatural combination of fire-power and supersonic speed.

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The Lockheed Electra has been specially designed to take advantage of this new concept in aircraft power, and represents another major advancement in air transport.

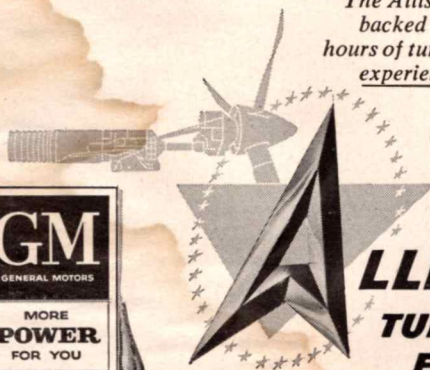
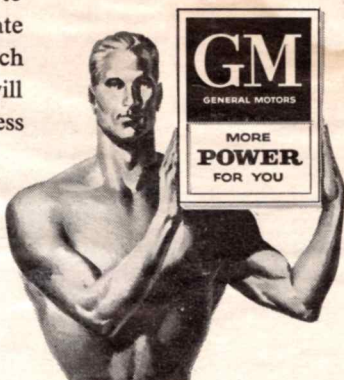
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AMERICAN BUILT FOR THE NEW ERA IN AIR TRAVEL

For further information circle Reader Reply No. 4

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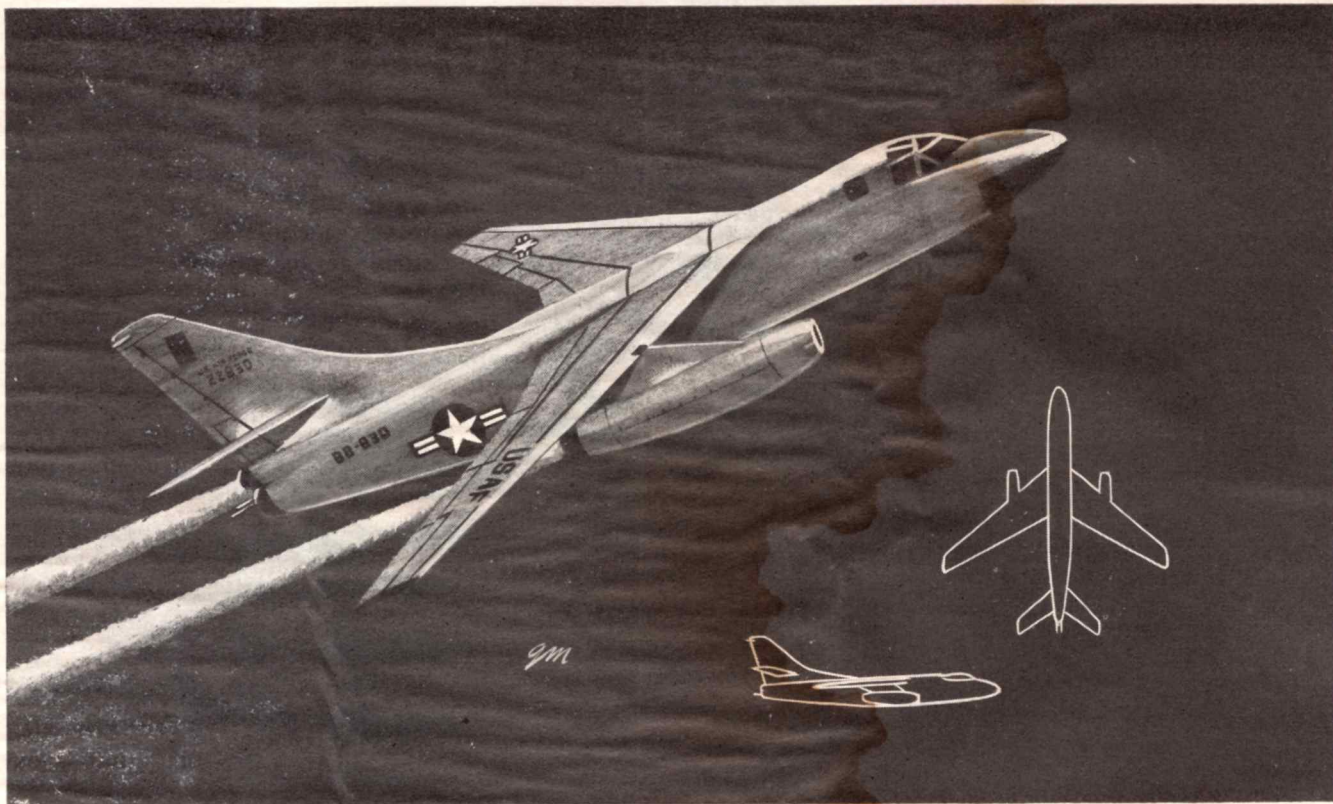
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DOUGLAS B-66B

New medium bomber strikes from treetop level or 8 miles up

Designed to fly at all altitudes up to 45,000 feet, the B-66B can carry a wide variety of bomb combinations.

Thrust from J-71 engines puts the three-man twin-jet in the 600-700 mph class. And efficient power-to-weight ratio allows her to strike deep into enemy territory and return.

Douglas Aircraft Company's Long Beach Division is now producing the B-66B for the U. S. Air Force. Like other jets, the swift, swept-wing bomber has Inco Nickel and Inco Nickel Alloys at critical locations.

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AERO NEWS DIGEST

RICHARD S. BOUTELLE, president of Fairchild Engine and Airplane Corporation, tells **AERO DIGEST** that one of the most significant aviation developments of the decade since World War II lies not in fancy new aircraft, necessary though they may be, but in the practical application of air logistics to the every day supply of an air force. "It is being done today in Europe, in Lt. Gen. William H. Tunner's command, the United States Air Forces in Europe," Boutelle says. "It has revolutionary implications, implicit in one single figure: USAFE has been reinforced by the equivalent of more than five additional combat wings through the use of an air supply system hauling the critical items that used to keep fighters and bombers on the ground and send the AOC rate rocketing up.

"The Air Logistics System of USAFE has earned its way. It works and the proof is there. Our workhorse, the C-119 Flying Boxcar, has been put to a rigorous test in making the ALS operation work throughout the continent of Europe and into Africa and the Near East. The ALS doesn't have the drama of the Hump, of the Berlin Airlift or of the Combat Cargo Command in Korea, and so the full story has been known only to a relatively few, even among the military services. But the same basic principles learned by Gen. Tunner in these earlier dramatic applications of airlift have been applied to an aerial trucking system that is producing literally fantastic savings in time, money and material. Stockpiles—stockpiles that represent \$1.4-million for each day of supply—have been halved with a saving of more than 100 days or more than the \$140-million. Aircraft out of commission for parts stay on the ground days instead of weeks—the real pay-off for combat units.

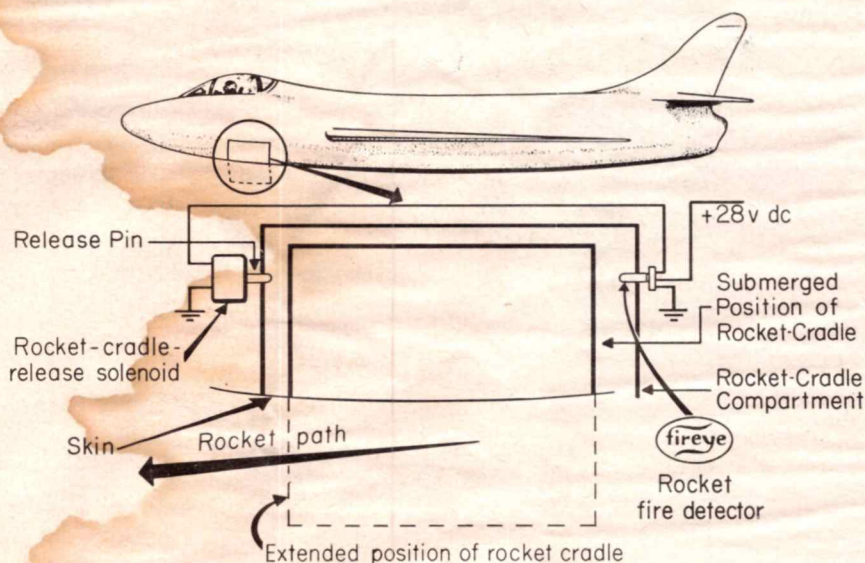
"Spectacular though the results of ALS have been, they are

only a pattern for development of entire new systems of military logistics. The Army is served by ALS, but only to a limited degree, a limit now imposed by the number of transport aircraft available. The implications for the Navy, in which a carrier fighter down on the hangar deck out of action for parts is even more critical than on land, are obvious. Multiply that figure of \$1.4-million per day of supply to a world-wide Air Force, add to that the savings possible to the Army in its motive power alone, plus the Navy's potential for savings in air logistics and the full potential scope of a true air logistics service emerges," Boutelle says. "No longer do we in the air cargo field have to encourage the dream of an air logistics concept. It is in being. It works, as Gen. Tunner has proved. It perhaps could be better, given a dream airplane. But

it works with today's airplanes and it permits the troop carrier airplane to pay its way day in and day out. It also has proved that the medium-size transport is ideal for an air logistics system carrying critical and high cost items, keeping filler cargo items to a minimum. Only on a few routes would a big transport pay its freight in the ALS service.

"Almost unheralded, air logistics has reached manhood, has proved itself and now needs only to be put to work," the Fairchild president concludes.

• • •
A NEW AIR TO AIR REFUELING CONCEPT that is expected to exercise a wide influence on the aircraft industry is the refueling equipment idea associated with the *buddy mission*. Such a mission involves two planes of the same type, one carrying the weapons and one



Sketch showing operation of new *Fireye* rocket fire detector, developed by Electronics Corporation of America. Tests have shown that a rocket fired improperly on some fighter planes can burn safely inside a submerged type of rocket compartment for only 300 milliseconds. The detector not only spots the spuriously fired or improperly released rocket well within the time required, but also actuates a relay which sets off the rocket-cradle mechanism to allow the rocket to burn out completely, in perfect safety to pilot and plane. Entire rocket compartment can be monitored with only one or two detectors. The fire detector, which is a complete detection system in itself, including its self-contained control section, is placed in the spot inside the submerged compartment that provides the detector with the most direct view of the compartment.

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Today Republic's famous Thunderjets and Thunderstreaks are in service throughout the free world. These planes, as well as the new RF-84F Thunderflash, form part of the striking arm of the air forces of the U.S. and other NATO countries. Soon to appear are the F-103 and F-105, while planes embodying advanced aerodynamic

concepts are already in the mock-up and prototype stage. Still others are on Republic's drafting tables.

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Assistant Chief Engineer

REPUBLIC AVIATION

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For further information circle Reader Reply No. 35

AERO DIGEST

acting as a tanker. Both planes would climb to altitude and fly at identical speeds. Then, somewhere enroute to the target, the two planes would go into refueling formation. The weapons plane would replace the fuel lost during the take off and climb, after which the buddy tanker is free to return to base. The operation can extend the range of the weapons plane, its load carrying capacity or its endurance over the target area.

What will the buddy mission equipment be like? Although a detailed description would be premature at this time, an approximate idea may be formed by considering two basic aspects of the operation: refueling contact in close formation and the flight speed and altitude envelope. Studies are currently under way to determine the method of actuation and the configuration of the exposed elements and specific operating and safety features applicable to several proposed installations. These studies include the development of specific prototype hardware.

The application of refueling gear to fighter aircraft places new emphasis on the weight and simplicity of the equipment. The nature of the aircraft and the application suggest that the equipment will be in the form of an external store with self-contained power supply and fuel storage, easily installed on and removed from the aircraft. (See aerial refueling article on page 27).

• • •

MORE THAN 150 ENGINEERS will be hired shortly by the newly formed Piasecki Aircraft Corporation, Frank N. Piasecki, President of the firm, tells AERO DIGEST. Needed are engineers and designers in all fields of aeronautics, with emphasis on vertical lift aircraft—"not only for rotary wing aircraft," Piasecki says. This is likely to mean that the company expects to work on all kinds of VTOL aircraft, including coleopters, ducted fan and jet lift devices.

Piasecki Aircraft Corporation is leasing three buildings and has entered an agreement to develop an aircraft manufacturing

area at the Philadelphia International Airport in Southwest Philadelphia. Piasecki says the company will have 43 acres of flight test area and occupy 1.9-million square feet of office and manufacturing space. The Corporation will specialize in the development of prototypes and the manufacture of the newest type aircraft.

• • •

INCREASING IMPORTANCE OF GUIDED MISSILES in the nation's defense recently was pointed up by Douglas Aircraft Company in separating missile engineering from aircraft engineering functions. During the 14 years the company has been in this field, development and design of guided missiles have been undertaken within the Santa Monica engineering department. The change in status of the missile organization was a recognition of the increasing proportion of engineering effort devoted to guided missiles.

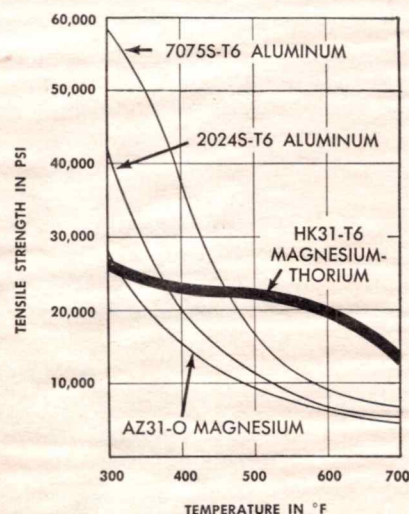
Douglas currently is engaged, alone or in collaboration with leading electronics firms, on eight major missile projects under contracts from the Air Force, Army and Navy. Among them are three missiles in production—*Honest John*, *Nike* and *Sparrow I*.

The new engineering department will be headed by Elmer P. Wheaton, as chief missiles engineer. Wheaton, who has been in the field of missile research and development since 1941, has headed such projects at Douglas since 1943.

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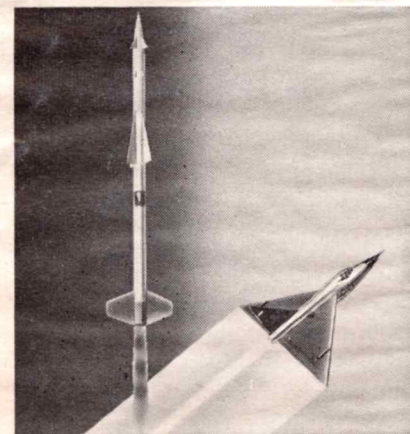
A NEW ALL-METAL AMPHIBIAN, the Colonial *Skimmer* C-1, received its approved type certificate on September 19, 1955. The prototype craft has been going through extensive flight tests and modifications since its completion in 1946. Many safety features have been incorporated. Engine pylon and nacelle are stressed for 20 g's, far exceeding the safety belt requirements. Visibility for pilot and passengers is increased by the forward location of the cabin ahead of the wing, also reducing the cabin's noise level. Engine is a Lycoming O-320 driving a pusher Hartzell constant speed

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For further information circle
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propeller. When approved, the prototype had a full length rudder, and this will be standard on future production models. The factory will be located in the New England area and the first production craft are expected in early 1956. Span of the *Skimmer* is 34 feet, length is 23 feet, 6 inches, and the overall height is 8 feet, 10 inches. Top speed is 127 mph at 5000 feet; it cruises at 115 mph at 62 percent power and landing speed is 50 mph. Gross weight is 2150 pounds, empty weight is 1450 pounds, useful load is 700 pounds. Range is 600 miles with one hour reserve of fuel. Gas capacity is 30 gallons normal or 45 gallons maximum. Standard equipment on the *Skimmer* includes two-way VHF radio and blind flight group of instruments.

. . .

APROPOS THE SIXTH ANNUAL NATIONAL NOISE ABATEMENT SYMPOSIUM held in Chicago last month, all this noise about noise didn't start with the first sonic boom. As early as 1936 a *Baltimore Sun* feature had this to say about the demon, sound:

"What, then, is this noise that so frazzles the nerves . . . that citizens rush gibbering to the police and the lawmakers for relief every once in a while? Science computes it in a measure of sound—decibels. A boiler factory, we are told, emits 101, yet Benjamino Gigli, Manhattan tenor, attains 77 at high C, or twelve times the noise of a street car, and people sit enraptured. Small comfort in a meter that cannot distinguish between music and noise . . . A Canadian educator held that a bedlam made people unhappy, a New Jersey expert that it made folks think, and a British medico saw deafness as the principal evil. Yet a Swiss doctor recommended more noise as a counter-balance for other sounds which alone might bring nervous complexes. A New York health commissioner warned that noise created gangsters, while that city's Noise Abatement Commissioner added that it stunted growth, as witness a cage full of experimental mice.

And to top it all, a Pennsylvania psychologist stoutly maintained that despite the tossing of thousands, noise aids sleep, instead of disturbing it. One is forced to wonder what would happen if all auto horns were removed, all radios silenced and other mechanical noises abated? Would the bungling bottle-fly in the room, the man who pops his knuckles, the fellow who whistles and the scraping of a limb against the house be regarded with a smile of complacency or would they succumb to a campaign?"

Author of this article was then reporter for the *Baltimore Sun*. He is Avery McBee, now Director of Public Relations for the Aircraft Industries Association, where the noise problem continues at times to haunt him—twenty years later.

. . .



Colonial *Skimmer* nosewheel acts as a bumper under water taxiing.

. . .

AMONG THE TOP COLLIER TROPHY CANDIDATES for 1955 are William M. Allen of Boeing (jet transport development); Richard T. Whitcomb of NACA (area rule design); Hiller Helicopters (ducted fan platform), J. F. "Skeets" Coleman, Convair test pilot (vertical take off flight); Col. John Stapp (rocket sled) and Dr. Hugh Dryden of NACA.

. . .

BRISTOL AEROPLANE COMPANY hopes to reduce loss of power with increased altitude with the new BE25 turboprop engine to be fitted on the *Britania*. The company says it had four basic design objectives in mind for the new engine: to provide 3500 ehp for cruising at 30,000 feet; to provide as nearly as possible constant take-off power for any airfield in the

world; to obtain a fuel consumption better than that of any piston engine; to exploit fully the turbine's ability to give high power for a small weight and bulk.

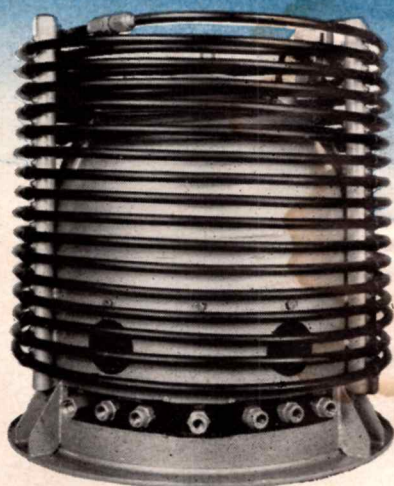
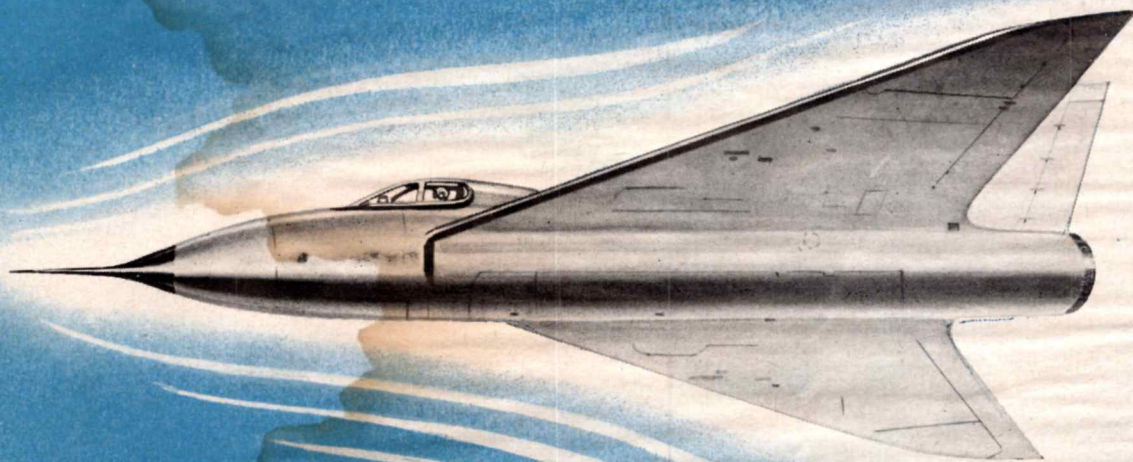
The problem of reducing power loss at altitude was overcome in the case of the piston engine by supercharging, and the same idea has been applied to the BE25. The engine consists of a high pressure compressor, combustion system and high pressure turbine, forming a unit similar to a single-spool turbojet. The high pressure system is supercharged by a low pressure compressor driven by low pressure turbines using the exhaust from the high pressure system. The low pressure system is geared to the propeller. There are two basic controls—a throttle, regulating the power and speed of the high pressure system, and a propeller pitch control conventionally operating through a constant speed unit and so governing the speed of the low pressure system. The division of compression between the two stages has been chosen so that whatever the speed ratio between them, neither shall run into a surging condition.

The engine is comparable in size and weight to the *Proteus*, dimensioned and stressed for about the same horsepower, but differing in the additional possession of a supercharging compressor to maintain that power at cruising height.

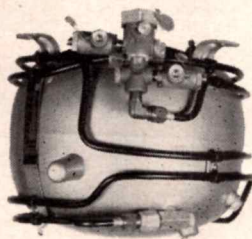
Such an engine would produce greater power at lower altitudes—in fact over 8000 ehp at sea level. This is very much more than can be foreseen to be necessary, and there was much to lose and nothing to gain by stressing the unit to withstand it. The obvious remedy, following supercharged piston engine practice, was to limit the full throttle power and so avoid having to provide a reduction gear and propeller which would be unnecessarily heavy throughout the vast majority of the engine's working time, according to Bristol.

The full throttle power is therefore limited to 4000 shp or about 5000 total horsepower and this limit operates from sea level to 17,500 feet after which power falls off with increase in altitude in the usual way. In consequence

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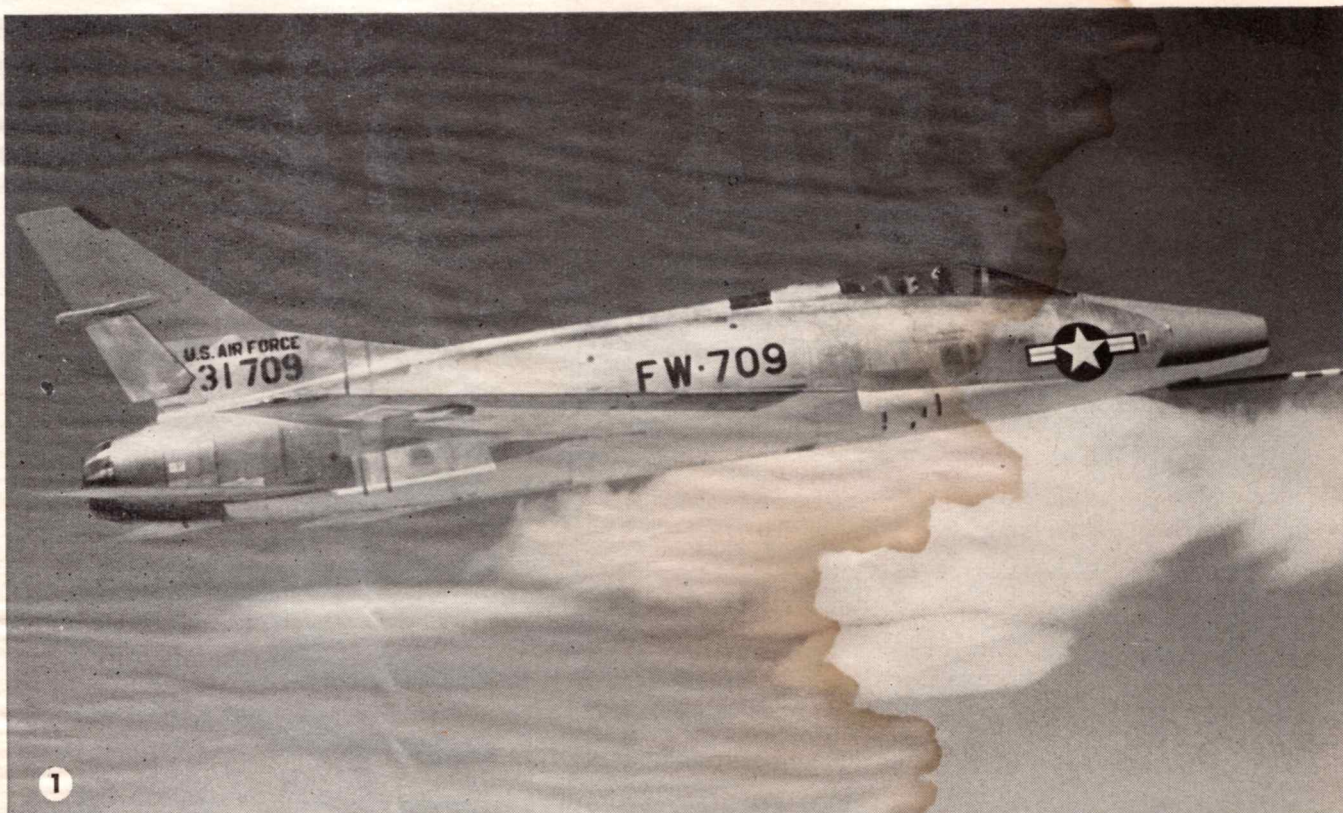
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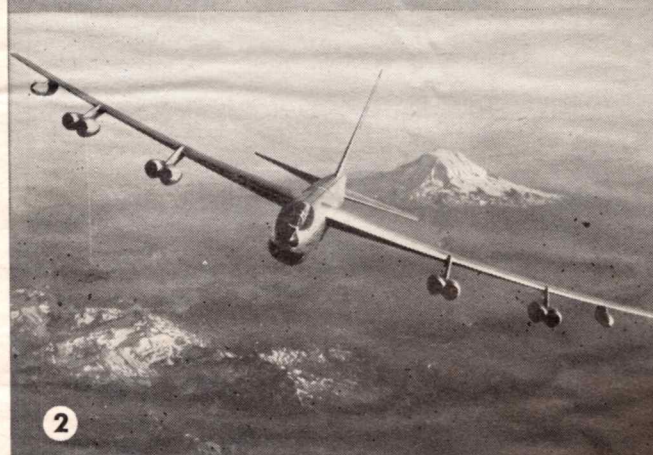
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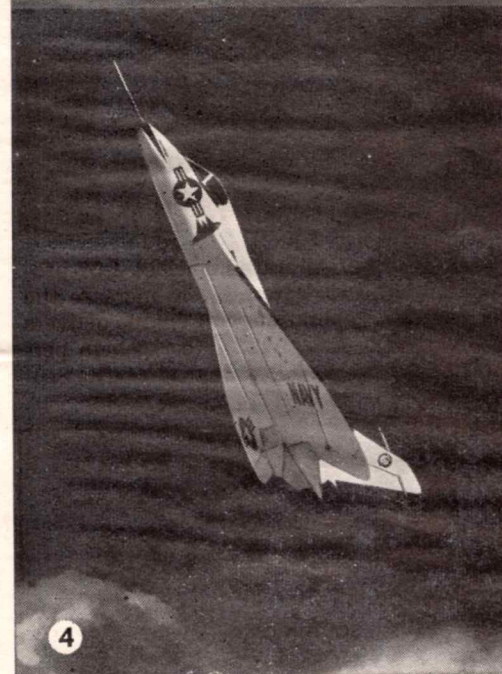
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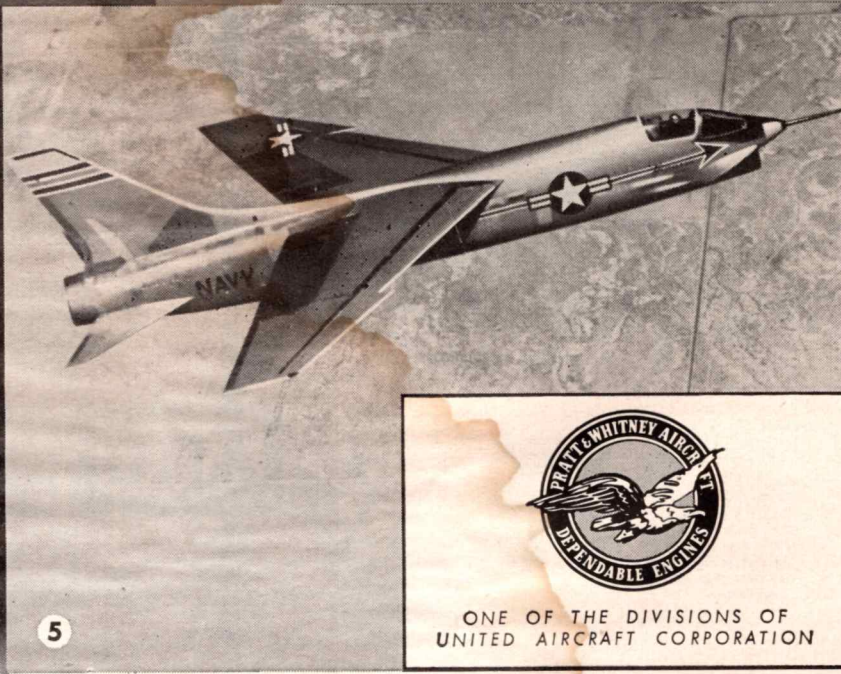
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4



5



ONE OF THE DIVISIONS OF
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THE FASTEST FLY WITH THE J-57

In the Air Force, J-57 turbojet engines power the fastest fighters—including the holder of the official world speed record. In the Navy, J-57s power the fastest carrier-based aircraft, fighters capable of supersonic speeds in level flight. The mighty B-52, new strength of the Strategic Air Command and the fastest bomber, is powered by J-57 engines, as is the fastest transport now flying, the 707 prototype jet tanker-transport.

In all of these powerful aircraft, and in many

others, Pratt & Whitney Aircraft's J-57 advanced turbojet engine has been chosen to meet the exacting requirements of high thrust rating, reliability and efficiency.

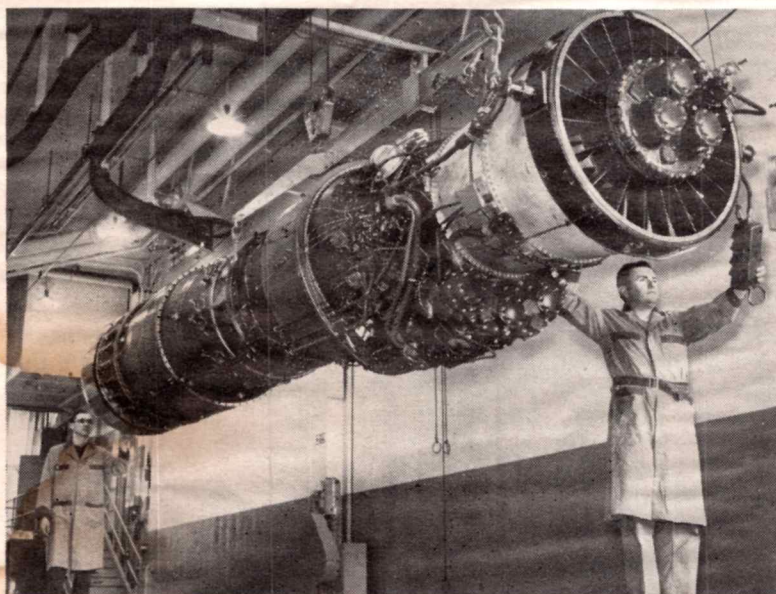
The leading land-based and carrier-based fighters, the new mainstay of the heavy bomber fleet, and the jet transports are all designed to take advantage of the performance of the J-57 engine. Pratt & Whitney Aircraft's J-57 is continuing to make its vital contribution to American air strength.

1. SUPERSONIC RECORD HOLDER—The North American F-100C holds the official world speed record, 822.135 miles per hour. Already in operational use in the USAF Tactical Air Command, the F-100C Super Sabre can deliver an atom bomb at high speed.

2. MIGHTIEST OF THE BOMBERS—The Boeing B-52 Stratofortress uses eight J-57 engines hung in pods under the wings. Now in units of the Strategic Air Command, the B-52 can be refueled in flight to extend its range as needed. Speed is over 600 m.p.h., ceiling over 50,000 feet.

3. JET TANKER-TRANSPORT—Boeing's 707 prototype, with four J-57s, is the fastest transport and the first of a new family of advanced jet aircraft. The Air Force has ordered production of a tanker-transport version, the KC-135. As a commercial transport, the aircraft could carry from 80 to 130 passengers, cruising in the 550 m.p.h. range.

4-5. FASTEST NAVY FIGHTERS—The Douglas F4D Skyray, left, with delta wing, set a 753.4 m.p.h. record on a three kilometer straightaway run. The new Chance Vought XF8U-1 Crusader, right, with swept wing, features a trim, lightweight airframe and uncluttered design. Both are equipped with afterburners, and can exceed the speed of sound in level flight.



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The limitation of power is simply achieved. The reduction gear incorporates a floating annulus gear reacting against pistons to balance torque against oil pressure. The maximum torque limit is thus checked by a reduction in fuel supply. The analogy is thus clear between this engine and the automatic boost controlled piston engine.

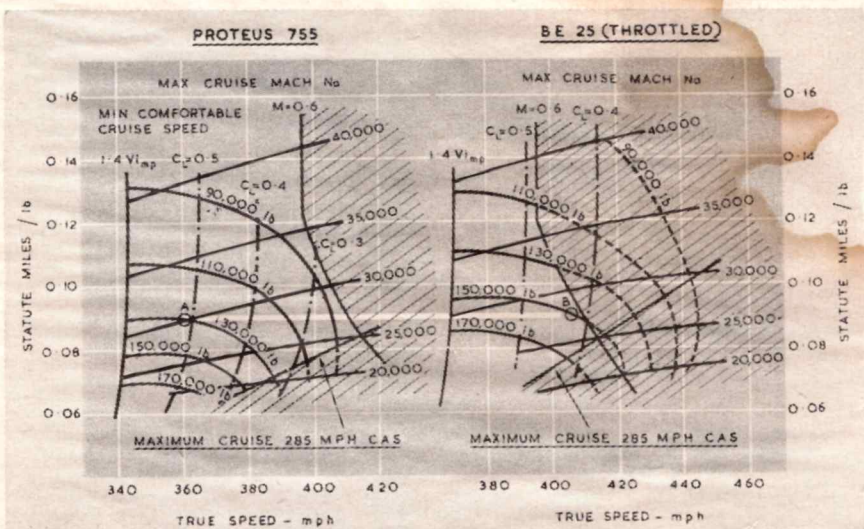
DR. WERNHER VON BRAUN has just completed another technical advisor assignment for Walt Disney Productions. He has assisted in designing a moon ship that will be featured in *Man and the Moon*, a new Disneyland presentation to be presented over the ABC TV network December 28. *Man and the Moon* is a continuation of *Man in Space*, Walt Disney Productions tells AERO DIGEST. It depicts the construction of a space station 1075 miles above the earth, followed by a realistic rocket flight around the moon. Dr. von Braun appears on the program to explain and narrate the space station sequence.

THE CONVERTIBLE AIRCRAFT PIONEERS are scheduled to hold their Third National Congress on November 26 at the Franklin Institute in Philadelphia. National Chairman of the group, E. Burke Wilford, tells AERO DIGEST that the German aircraft designer and rotary-wing expert, Dr. Heinrich Focke, who is presently in Brazil, will be invited to

the Congress. Reports from the convertiplane work of the Army, Navy and Air Force will be given by high ranking officers, and Arthur Young, of Bell Aircraft, is scheduled to talk on the XV-3. Mr. Wilford will present a paper on high-speed hybrid aircraft.

GENERAL ELECTRIC COMPANY has launched an interesting and different advertising campaign. Scores of small businesses that have helped GE in completing defense contracts now have facilities for continued production of specialized items, and GE has undertaken to advertise and announce the availability of the services of these firms. As the Armed Services iron out the high volume peaks brought about by the Korean crisis, some of the highly trained GE subcontractors have the capacity to work on other civilian or defense projects. GE's long established policy of sharing defense orders with small business means that these small companies have the knowledge and ability to meet exacting specifications and produce parts and assemblies with speed and efficiency. Their special skills, tools and machines contribute greatly to the defense effort, in speeding production and in cutting costs. According to GE many have diversified their subcontracting activities and have developed marketable products of their own, thus adding to the peacetime economy.

ERIK BERGAUST



Comparative curves illustrating the typical increase in performance that could be obtained by substituting BE25 power plants for Proteus 755 in the *Britannia*.

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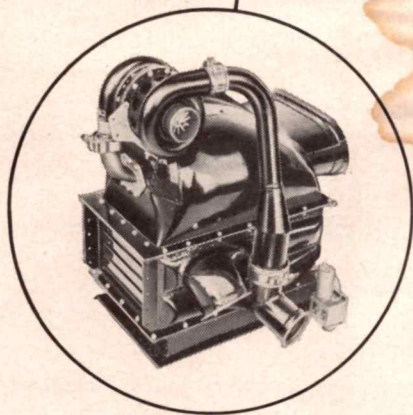
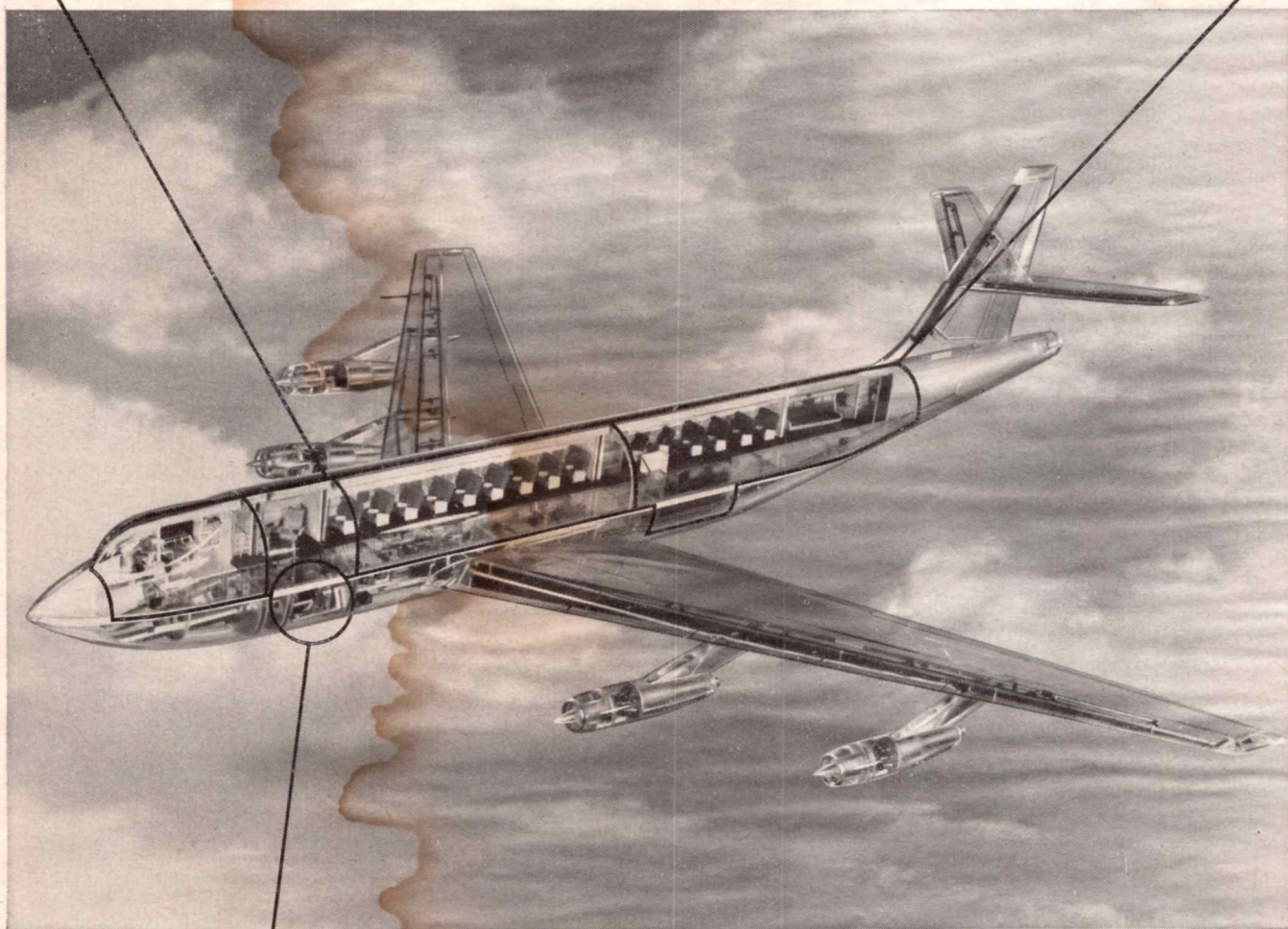
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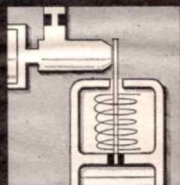
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AVIATION ENGINEERING

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for December

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• Ballistic Missile Powerplants Can Be Controlled

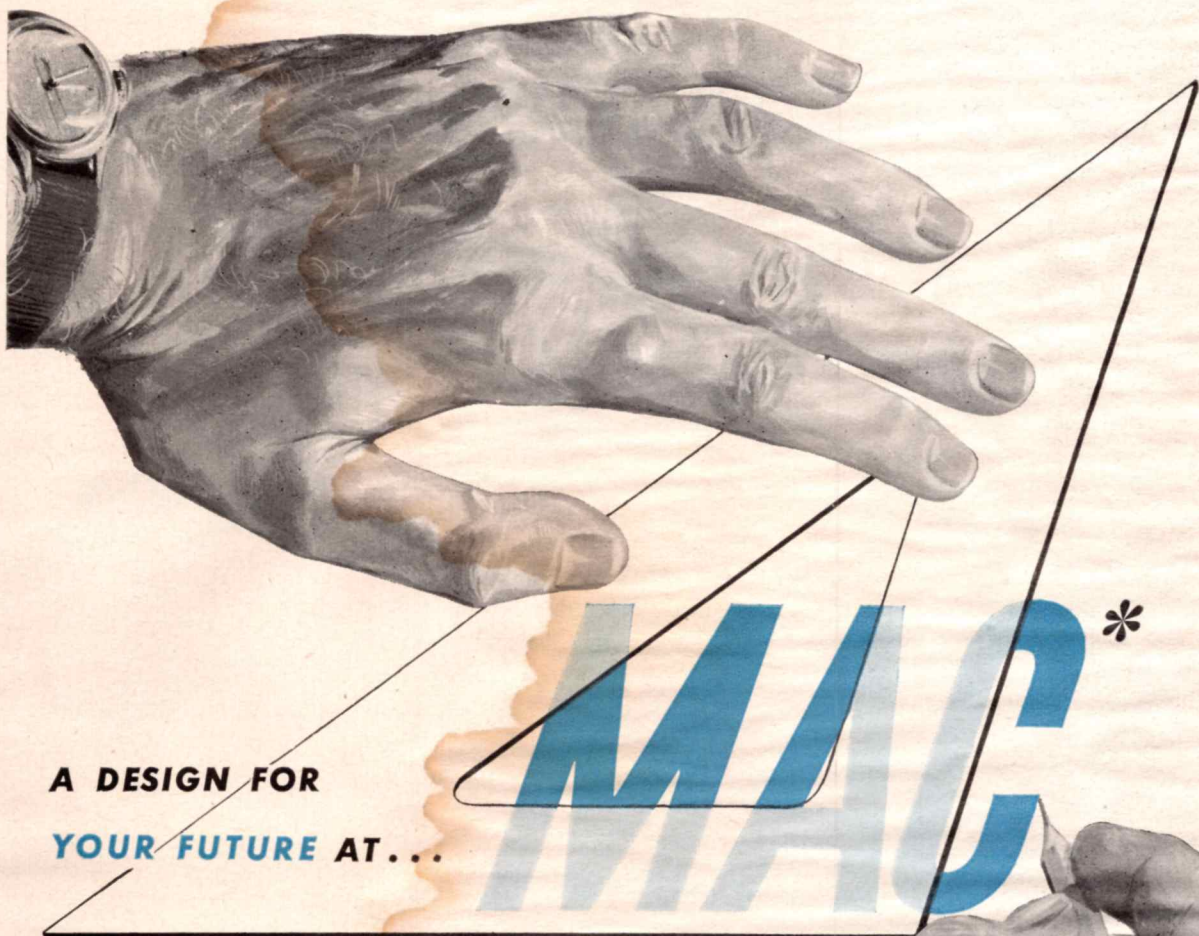
During static test and flight, rocket engine control is vital but difficult. New and important techniques are given by rocket engineer R. Reichell of Bell Aircraft.

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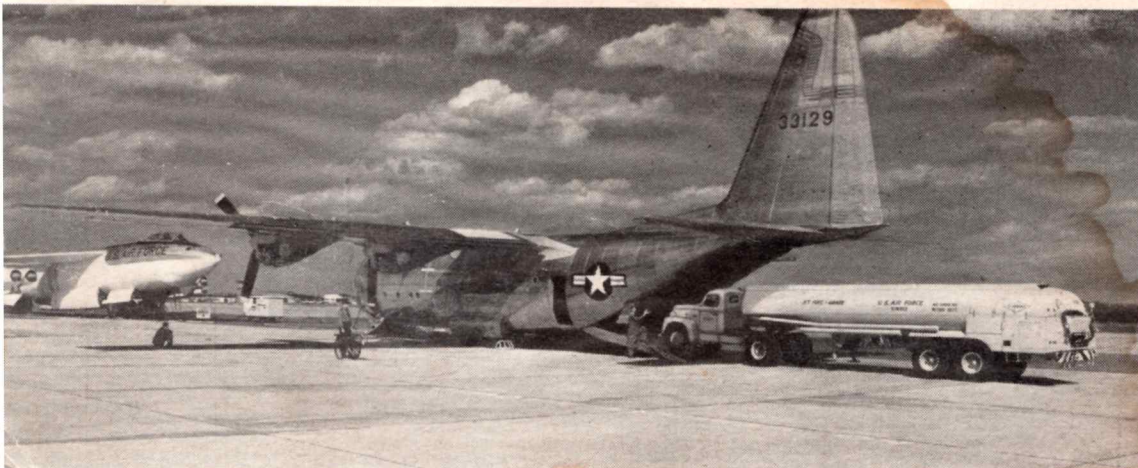
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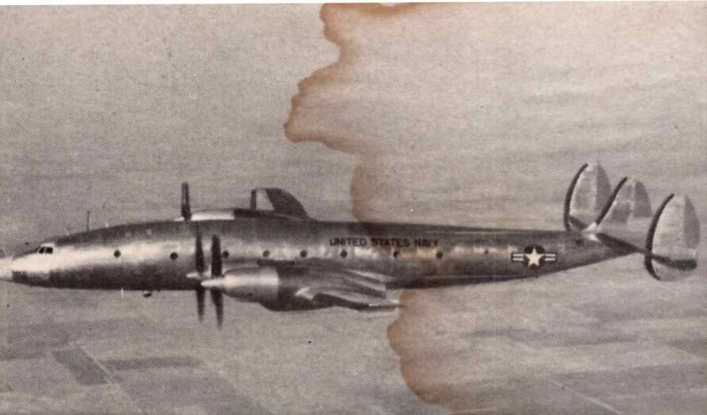
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F-104, STILL-SECRET JET FIGHTER. (Photo restricted.) A top USAF officer said: "This is a fighter pilot's dream. We feel confident that it is the fastest, highest-flying fighter in the air, anywhere."

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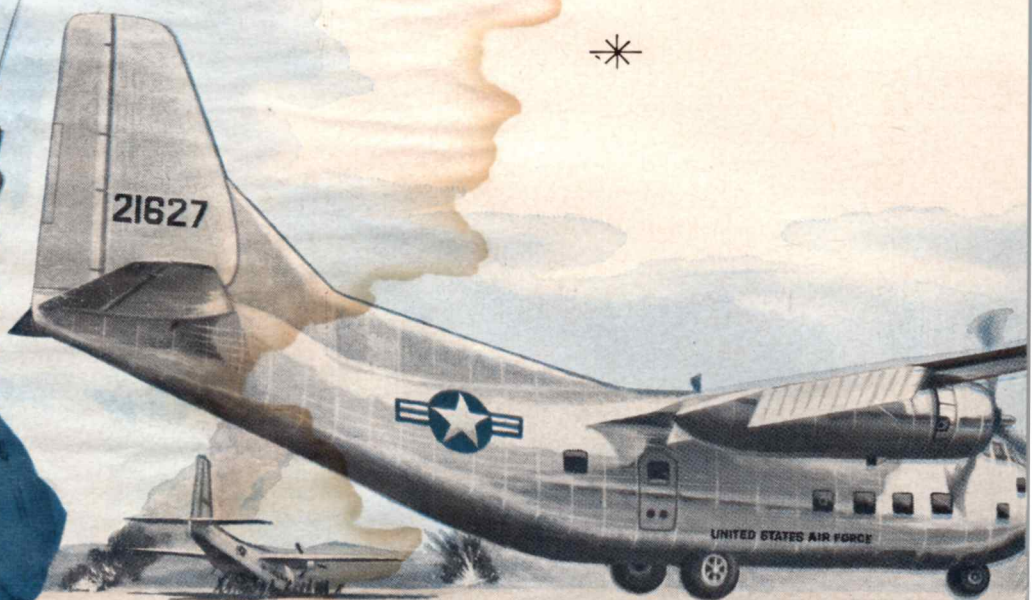
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There Is No Ultimate Weapon

IT MAY BE A SAD FACT TO CONTEMPLATE, but as long as we have machines we must have men to work them. True, we can build computers that will give us the best of all possible answers. Still, we must tell the machines the value of each factor, and then arrange the machine to manipulate itself to reach a conclusion.

Similar reasoning shows we cannot construct a completely automatic missile. We can prescribe that it fly thousands of miles, that it consult built-in maps for present position, and that it home on its target. We cannot prescribe that it recognize targets; much less, that it learn how to go on to other targets if the first one has been moved. If these simple instructions cannot be followed, then how can we ever expect to build an ultimate weapon—one that a push button would unerringly send to seek out and completely destroy critical targets?

If we assume a war, which every missile manufacturer prays will not occur but must assume, then for air supremacy we must look at the weapons system in terms of the objective of that system. Out of the needs arising will be formed the specifications for future missiles.

From here, we must build equipment for man and around man so that he can handle it and monitor it. The inter-continental ballistic missile concept is excellent—but it will only in the narrow sense be completely automatic. We must still augment our air strength with piloted aircraft.

If a perfect weapons system could be devised, it would be close to this: a mixed strategic force, each component contributing to the overall defense plan. We would need near to 100 percent reliability of men and equipment. We would therefore have to design equipment simple to operate and easy to produce. We would have to gain further military advantage by establishing posts in the upper atmosphere. Even so, we would not have the ultimate weapon. At most, we would have the best weapon—and not necessarily for all time.

* Formerly Commanding Officer of the Peenemünde Rocket Research Institute, and author of V-2.

DR. WALTER DORNBERGER*
Bell Aircraft Corporation

Ducted fan permits use of small diameter propellers. V-belt drive simplifies power transmission. Existing problems include too much stability, and an unbalanced torque if one engine fails.



First free flight of the Hiller platform on February 4, 1955.

Designing and Testing the HILLER PLATFORM

By ARTHUR C. ROBERTSON

Project Engineer
Hiller Helicopters
Palo Alto, Cal.

THE REQUIREMENTS for an Airborne Personnel Platform impose a new standard on the designers. First, it must be easy to fly, so easy that a soldier could learn to fly it with only a few minutes' practice. The aircraft must be small to be able to be operated safely out of extremely confined areas. It must be light so that it may be transported easily to the battle area by any military vehicle. It must be of simple, inexpensive, rugged construction so that initial cost and maintenance are low. It must be capable of vertical and hovering flight as well as forward flight.

Hiller Helicopters has always been interested in simplifying flight. In 1946 this interest led Stanley Hiller to Charles H. Zimmerman, who was experimenting with an unusual idea for simplified flight control.

Zimmerman reasoned that if an instinctive response could be used to control an aircraft, people could learn to fly with little or no training: they would already possess the necessary skill to fly. With this goal in mind, he conceived the idea that a small aircraft capable of hovering and rising vertically as well as flying in translational flight could be stabilized by a man in a standing position. A person's body is in unstable equilibrium when standing erect on a solid surface; his reflexes are constantly acting through his muscles to preserve his equilibrium. Zimmerman felt that this same reflex response could be used to balance a person standing on a hovering Platform. Figure 1 illustrates this idea. If a person

standing on the ground leans forward, his weight is supported on the balls of his feet. This results in a moment about his ankles resisting the tendency to fall forward. If this person were standing on the Airborne Platform in flight and leaned forward, his weight would again be supported on the balls of his feet. This pressure on the balls of the feet would produce a moment about the ankles resisting the tendency to fall, and in addition, would tilt the Platform forward, causing the thrust vector to pass ahead of his center of gravity and thus create an additional correcting moment. For this reason, the instinctive reflex responses that stabilize a person standing on the ground operate in the proper sense,

but not in the proper magnitude to stabilize a person on an Airborne Platform.

In order to test this principle, Zimmerman built the test machine shown in Figure 2. The craft was powered by two engines arranged side by side with the pilot standing between their propellers.

During the early 1950's, NACA became interested and built two machines for test purposes. The first of these was powered by a compressed air jet. The jet nozzle was attached, facing downward, to a foot-board, upon which the pilot stood. The compressed air was piped to the Platform by flexible hoses. Flights were made with the pilot in a safety harness suspended from an overhead cable.

The second machine was powered by a compressed air-driven rotor. The air was again carried to the Platform through flexible hoses and the craft was flown in the same safety harness used for the jet Platform.

Hiller Helicopters watched these tests with a great deal of interest and submitted a proposal to the Office of Naval Research to study various Platform designs with self-contained powerplants. ONR, in late 1953, awarded the company a contract to design, fabricate and test a flight vehicle.

Upon reviewing requirements for the ideal individual aircraft, it was evident that the Airborne Platform could fulfill at least two of the needs: it could be flown with little or no instruction, and it could be capable of hovering and vertical flight.

● ● Ducted Fan

Turning to the problem of size, the designers found that shrouded propellers offered important advantages. When propellers are properly shrouded, they

produce the same thrust as unshrouded propellers of 40 percent greater diameter; therefore the shroud yields a substantial reduction in the diameter of the rotors and in the size of the Platform. This reduction in rotor diameter allows the rotors to turn at higher rpm for a given tip speed, which simplifies the gear reduction problem from engine to rotor. The reduction in size is also important from the standpoint of control: it reduces the moment of inertia of the machine about the pitching and rolling axes. Such reduction is particularly desirable about the pitching axis because all the pitching forces generated by the pilot must be transmitted through his ankles, and the strength of his ankles is limited. An additional advantage of the shroud is the protection it gives the propellers when the craft operates in confined areas and the protection it gives to personnel around the machine.

The instinctive control feature inherent in the platform principle simplified the craft by eliminating the control system and the need for cyclic pitch in the propeller blades. Controlling thrust by changes in propeller rpm eliminated the need for collective pitch in the blades; propellers could be simple by using fixed pitch propellers similar to those used on light airplanes.

Using a single propeller was considered early in the design. Although it would have eased the drive system design, considerable development would have been necessary to balance the torque and gyroscopic moments. In order to avoid these problems and the attendant development, counter-rotating propellers were chosen.

To keep the size of the Platform to a minimum, the duct and propeller diameter had to be reduced to a minimum, consistent with the weight to be lifted

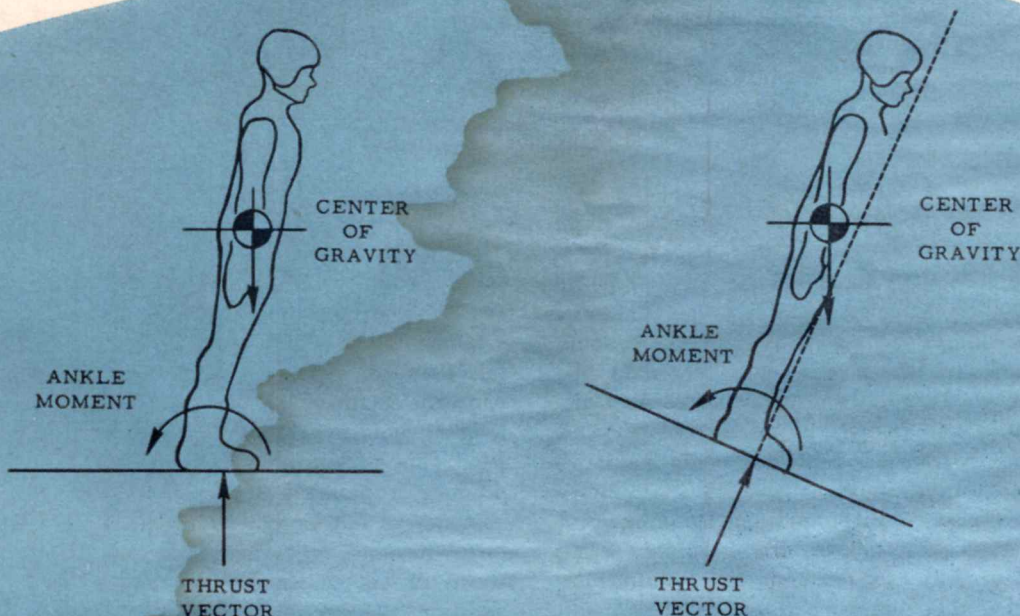


Figure 1—Balance diagram illustrating the basic principle of platform flight.

Platform

and the power available. Being a research craft, the platform had to carry only the pilot and sufficient fuel for short flights. From this useful load, the gross weight was estimated. Preliminary estimates of the power required and the propeller diameter were made that would allow some latitude in weight and thrust.

● ● Design

Having established the size of the Platform and selected the powerplant, it was possible to establish the general arrangement of the components. From this general arrangement, more detailed weight and performance estimates were made. These indicated that the machine had sufficient excess thrust to allow for unforeseen changes affecting either the weight or thrust. The only decision to make before detail design was the selection of a suitable propeller drive system. The two drive systems considered were a gear box with input pinions from each engine which would drive output gears to each propeller and an independent V belt drive with each engine driving one propeller. Gear box design and fabrication are time consuming and costly and usually require some development before a satisfactory unit is completed. Considering the objective of the program, which was to study Platform flight, it appeared advisable to use the V belt drive system.

Admittedly, this independent propeller drive system would result in unbalanced torque in the event one engine should fail. However, the early flights were to be made in a safety harness which would catch the craft and pilot in the event of loss of control. Such a safety harness would allow flight tests to be conducted in safety without compromising the flight characteristics of the machine. Therefore, it appeared that the best interests of the program would be served by simple, independently driven propellers.

These decisions established the basic arrangement of the machine: counter-rotating propellers surrounded by a shroud, the pilot standing above the thrust vector, and two engines. To provide adequate room for the pilot over the thrust axis, designers arranged the engines one ahead of the pilot and the other behind him. The selection of a belt drive system made it necessary to install the engines vertically so that the engine crankshafts would be parallel to the propeller drive shafts. Although the engine was designed to operate horizontally, the only modifications necessary were the selection of a suitable horizontal throat carburetor and a slight revision to the manual starter. These changes were made by the engine manufacturer prior to delivery of the engines. In order to drive the propellers in opposite directions, it was necessary that the engines turn in opposite directions: because of the nature of the rotary valve within the engine, it would have been difficult to reverse the direction

of one engine. Therefore, one engine was mounted with the crankshaft down, and the other engine with the crankshaft up.

● ● Structure

The structure for the machine proved to be simple. A center fitting supports the propeller drive shafts and the floorboards upon which the pilot stands. Extending out from this center support are four beams of streamlined shape. These beams extend through the duct and support the duct and the landing legs, Figure 3. The engine mounts rest on the radial beams and the center support.

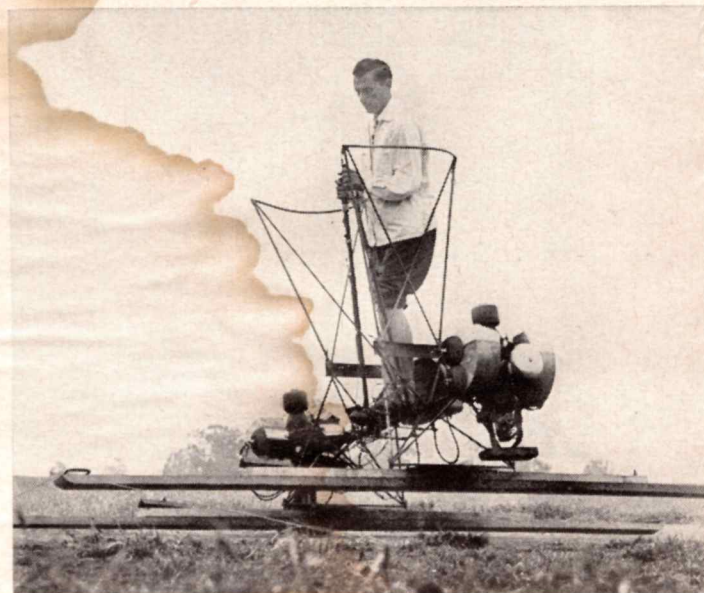
The duct is made in two pieces, the propeller shroud and the inlet duct. This duct is essentially non-structural and rigidity is the primary requirement, particularly in the case of the propeller shroud. For rigidity, the propeller shroud is of sandwich construction, consisting of 0.012 aluminum skins with a foamed-in-place plastic filler. The inlet duct is made of plastic impregnated fiberglas. The mold for this inlet duct was designed so that the inside surface of the duct, which had to have a smooth surface, was next to the mold.

The landing gear is composed of four vertical struts, one at the end of each radial beam. These struts telescope into the landing gear brackets bolted to the ends of the beams. The landing impact loads are carried by two bungee rings on each strut.

Surrounding the pilot about waist high is a safety ring. This safety ring, in addition to boosting the morale of the pilot, allows him to damp severe oscillations with the aid of his hands. The safety ring also provides a convenient support for the throttle control. This is a twist-grip type control located to enable operation by the left hand; the control is connected to both engines by a push-pull cable so they operate together. Climb and descent are controlled by throttle setting.

The fuel system is also unsophisticated, consisting of a fuel tank mounted atop the forward engine and

Figure 2—The original Zimmerman Platform during the test program at Hiller Helicopters plant in 1947.



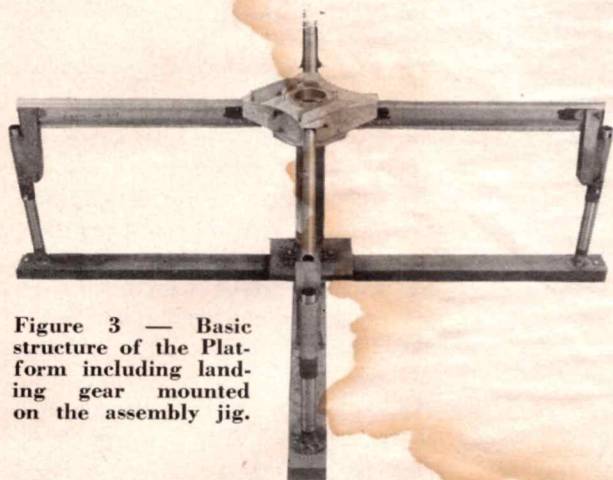


Figure 3 — Basic structure of the Platform including landing gear mounted on the assembly jig.

a fuel strainer with an integral shut-off valve screwed into a fitting on the bottom of the tank. From the strainer, separate fuel lines extend to each carburetor; an engine primer is used in the system at each carburetor.

The engine relies on a 6-volt battery-ignition system which is powered by a small storage battery weighing just over one pound.

● ● Static Test

In September 1954, after eight months work, the design and fabrication were completed and the platform was ready for test. Before the craft could be flown, some static testing was necessary to check the thrust, engine cooling and the propeller drive system. Because of the nature of the aircraft, it was impossible to predict accurately the local cooling environment around the engines. In line with the policy of simplest approach, the engine cooling problem was left to be developed during these tests.

The tests were conducted on the test stand shown in Figure 4. Here, the Platform was suspended from a cable, one end of which was attached to a thrust measuring scale. Sufficient ballast was added to the parallelogram arms of the test stand so that the weight always exceeded the maximum thrust. The thrust was measured as the difference between the scale readings with and without power. The cable system was arranged so that the machine could be tested at any height from zero to eight feet above ground. This allowed tests to be run throughout the entire range of ground effect and beyond.

The first runs were merely shake-down tests to allow personnel to become familiar with the operation of the machine and observe its general performance. During these tests, only two problems of any consequence developed. The gravity-feed fuel system was inadequate at high power settings, and the propeller drive V belts vibrated severely. To overcome these problems with a minimum of delay, the designers added a small electric fuel pump to the fuel system and idlers to the V belts.

The solution of these problems left only the engine cooling problem to solve. This proved to be the most

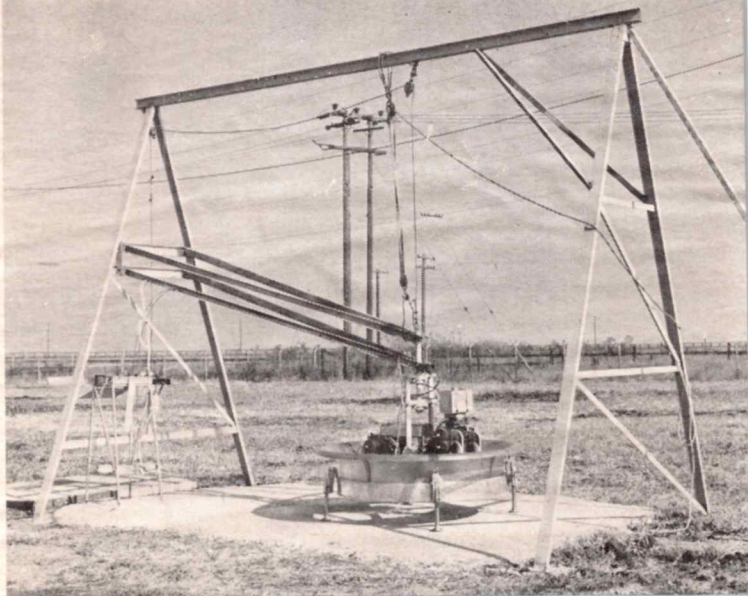


Figure 4—Platform installed on the static test stand in preparation for static tests.

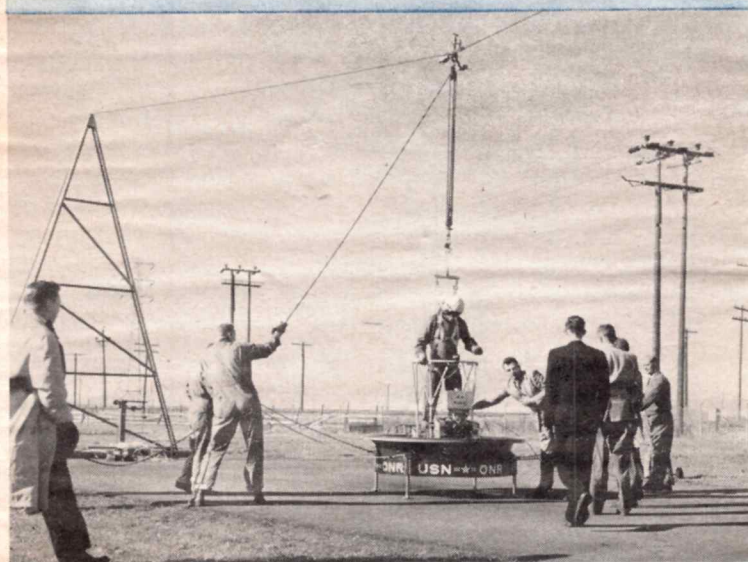


Figure 5 — Platform installed on the safety harness just prior to the maiden tethered flight.

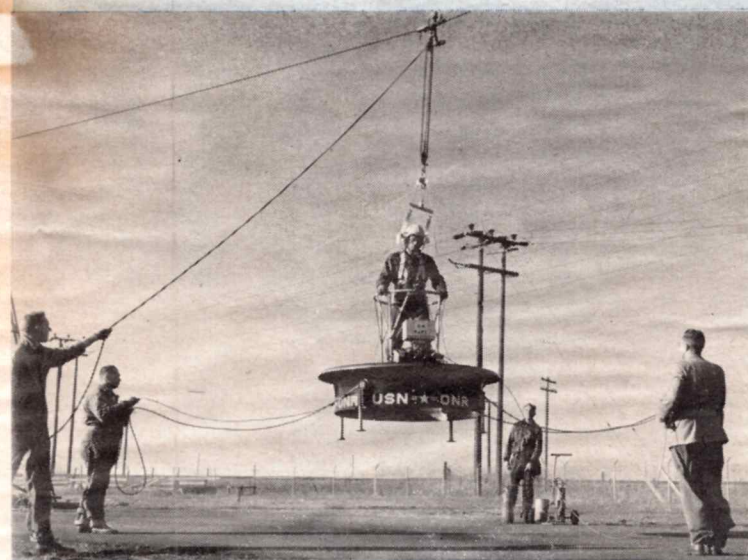


Figure 6—Pilot Phil Johnston takes the Flying Platform on its maiden tethered flight, January 21, 1955.

Platform

difficult one of all. Satisfactory cooling was finally achieved by installing closely fitting shrouds around the barrels and heads of the cylinders and extending them down to the propeller plane so that cooling air was pulled around the cylinders by propeller suction.

At the end of these tests, the platform was ready for flight. The safety harness used is shown in Figure 5. The A frames supporting the overhead cable were 80 feet apart and 22 feet high. The harness was suspended from a pulley on the cable so that the harness could move along the overhead cable between the A frames. Inserted between the pulley and the safety harness was a block and tackle with sufficient mechanical advantage so that one man could easily lift the machine and pilot. This allowed a man on the ground to regulate the slack in the safety harness; in case of emergency, the platform could be caught without excessive free fall. The harness was designed to support the platform and the flyer. The platform support consisted of four cables, one to each of the four radial beams on the machine, and for the pilot, a parachute harness was suspended from two ropes. These ropes were of such length that the pilot had sufficient freedom of movement for maneuvering even if the cables to the machine were tight.

For the early flights, the throttle controls were attached to a long push-pull cable so the throttles could be operated remotely, allowing the pilot to concentrate on stabilizing and controlling the platform. A further precaution during these early tests was the use of yaw ropes installed on the landing gear brackets. The purpose of these ropes was to allow the test personnel standing close to the machine to steady it in case the pilot lost control or an engine failed.

● ● Flight Test

On January 21, 1955, all preparations had been completed. Nothing remained but to fly. With a test engineer operating the throttles, Phil Johnston, the test pilot, made a brief hovering flight, Figure 6. The flight was so steady and easy it was almost uneventful. A number of additional hovering flights were made during the next few days; the only difficulties encountered were with the safety harness.

The cables supporting the machine interfered with the pilot's freedom of motion. A spreader was added to these cables up near the attachment to the lower block, with a few other minor adjustments, the safety harness ceased to be a problem. Following these hovering flights, a number of translational flights were made along the overhead cable. By this time, the pilot was quite familiar with the machine and the throttle control was installed on the safety ring so the pilot had complete control. Subsequent flights were made to study flight characteristics under all conditions pos-

sible within the confines of the safety harness. Translational flights were made backwards, forward and sideways, into the wind and with the wind. All the flights were made at low altitudes, the maximum the safety harness would allow being about ten feet.

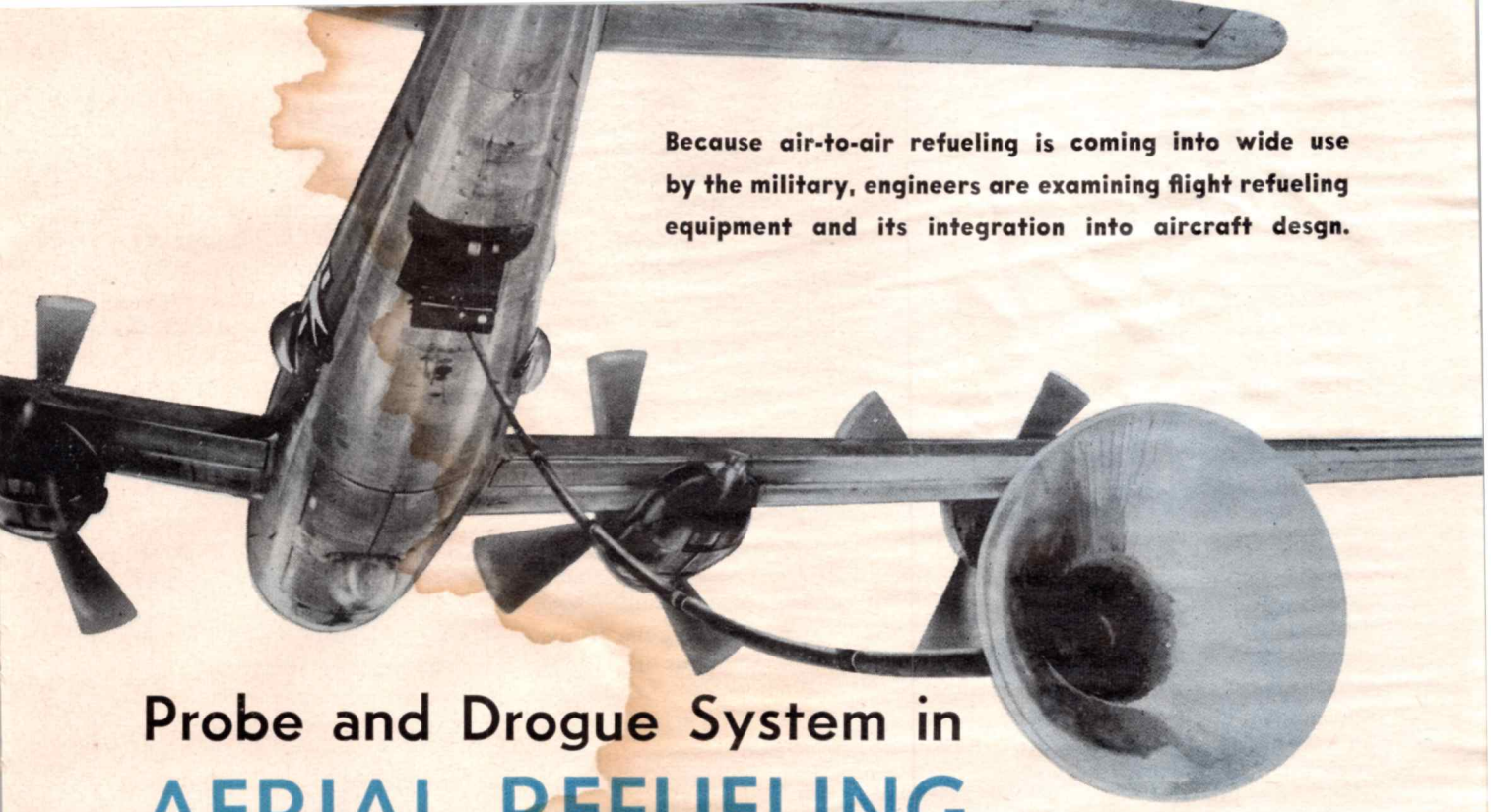
The tethered flight tests, although successful, raised the question of how much the safety harness was interfering with the flight characteristics of the machine. It was desirable to check the free-flight characteristics and the effect of the safety harness. The mechanical performance of the machine, which was the major safety problem, had been excellent, and a few brief free-flights were agreed upon. The first of these free-flights was made on February 4, 1955. Together with subsequent flights, it did not reveal any new or unexpected flight characteristics. The platform flew smoothly and easily, essentially as it had on the safety harness.

● ● Conclusions

The flight test program indicated the feasibility of this type of aircraft. The platform is easy to maneuver and control by instinctive reflex response. Because of the relatively powerful control forces the pilot can produce by leaning his body, it is possible to recover from almost any maneuver or lateral disturbance quickly and easily. As soon as a new pilot discovers this, he quickly loses any fear he may have had that the platform would tip over. He has complete confidence in his ability to keep it upright. To fortify this confidence, he also soon discovers that the machine is inherently stable and that it tends to return to level hovering flight when it is tilted into forward flight. As a result, a flight on the airborne platform is a unique experience.

No new development is completely trouble free. There are mechanical and aerodynamic problems to be solved. The basic mechanical problem is, of course, to gear the engines together so an engine failure will not result in unbalanced propeller torque, causing the platform the spin. The aerodynamic problem is centered around the stability. Actually, the platform is too stable and would be easier to fly if the stability were reduced. Development is now progressing towards the solution of these problems. END





Because air-to-air refueling is coming into wide use by the military, engineers are examining flight refueling equipment and its integration into aircraft design.

Probe and Drogue System in AERIAL REFUELING

By **CHARLES A. SPEAS**, Project Engineer
Flight Refueling, Inc., Baltimore, Md.

PRIOR TO 1949, air-to-air fuel transfer systems were based on some method of passing a refueling hose between aircraft. The numerous schemes for doing this culminated in the *looped hose* system, developed in the early 1930's and used successfully for many years. This system required heavy installations in both tanker and receiver aircraft and imposed other operating limitations.

By the late 1940's, the requirements for flight refueling were outdistancing the performance of the looped hose system. The newer probe and drogue system, Figure 1, was developed by the Flight Refueling organization incorporating the following improvements:

- 1) Allowed higher flight speeds during refueling.
- 2) Allowed refuelings at higher altitudes.
- 3) Eliminated the refueling operator working in the unpressurized section of the aircraft.
- 4) Allowed smaller aircraft, such as fighters, to refuel.
- 5) Simplified operations and equipment.
- 6) Reduced contact time during refuelings.
- 7) Allowed more than one aircraft to refuel simultaneously from a tanker plane.
- 8) Placed the control of the refueling operation in the hands of the pilot of the aircraft receiving fuel.

Many engineers think of the probe and drogue system in terms of the hose and drogue, and the probe used by the receiver. This is natural since these are the only parts of the equipment visible from outside an aircraft. In the overall functioning of the system

the operation of these parts represents only a fraction of the functions performed.

The entire system consists of five basic parts:

- 1) Fuel transfer equipment.
- 2) Hose tensioning and stowage equipment.
- 3) Trailing members—the hose and drogue.
- 4) Coupling members—the reception coupling and nozzle.
- 5) Receiver aircraft equipment.

● ● Fuel Transfer Equipment

Flight refueling operations impose many qualifications upon the fuel transfer components. For example, it is desirable for tactical reasons to transfer fuel at a high rate of flow, minimizing the time two planes must remain in contact. In fact, the rate of flow is perhaps the most critical characteristic to be established for any given tanker and it has an extensive effect on the design of the overall equipment. Such factors as pumping horsepower, operating pressure, hose bore, and the weight and volume of hose stowage and tension control equipment tend to increase rather sharply with an increase in flow rate. For example, an in-flight refueling system using the hose reel unit shown in Figure 3 requires approximately 35 fuel pumping horsepower for delivery of the maximum rated flow of 300 gallons per minute; the hose reel portion of the total equipment weighs 600 pounds and occupies an envelope volume of approximately 20 cubic feet.

In addition to the flow-horsepower-weight considerations, the problem of pressure control is introduced by the nature of the receiver aircraft fuel system.

Refueling

This system (in particular the tanks receiving fuel) must not be over-pressured. Some means of insuring this must be incorporated into the fuel transfer system. The present Air Force requirement is that the refueling equipment maintain a controlled pressure of 50 psi (plus or minus 5 psi) at the receiver nozzle. The maximum is set as a protective limit and the minimum established to insure high rate of flow. Several factors in the operation complicate the ability of any device to maintain the pressure within the required accuracy: changes in fuel temperature and density, fuel boiling, relative vertical motion of tanker and receiver, turbulent fuel flow and the non-linear behavior of the variables concerned. In spite of these problems, satisfactory methods are being applied and new methods are under consideration. Basically, the problem is one of insuring that fuel is delivered to the refueling gear in accordance with the characteristic pressure-flow relationship of the fuel passage from fuel pump to the receiver nozzle. Pressure adjustment can be accomplished by changing pump speed, downstream orifice area, amount of pump by-pass, fuel dumping downstream or by a combination of these methods. Present equipment adjusts the pump speed until pressure and flow agree. Other methods of pressure adjustment are being developed for possible application in the future.

● ● Fuel Flow

The fuel pumps presently in use for one type of probe and drogue tanker are submerged hydraulically-driven centrifugal pumps, rated at several hundred gpm. While the single pump of this type is adequate for present equipment, higher flow requirements are suggesting the use of boost pumps submerged in the tanks to supply a vapor-free head to the main pump located near the hose reel.

In addition to the flow controls associated with fuel transfer, a valve is used in the system to open and close the line between the pump and the hose reel. This valve and a small vent valve are remotely operated by a sequencing switch on the hose reel unit. The fuel vent valve is closed during fuel transfer but opened under static conditions to allow the fuel lines to breathe and take care of expansion and contraction due to temperature changes.

Surge shocks, which occur when the column of fuel in the hose is suddenly stopped, have been recognized as a problem for some time. During flow conditions, over 100 pounds of fuel are traveling at a velocity of from 20 to 30 fps. The flow shut-off must be made gradually to avoid damage to the hose and to connecting components including the receiver aircraft probe. Sudden deceleration of the fuel can occur as the receiver aircraft tanks are topped off and flow is reduced. A coupling disconnect during fuel flow can cause a severe surge condition since the coupling is designed to close suddenly, without leaking, at disconnect. Surge shock due to premature disconnect is

avoided in current equipment by keying the fuel valve closure to hose motion so that the valve closes several feet (a second or so) before disconnect. In future equipment, which involves longer lengths of hose and higher rates of flow, the problems of surge suppression are claiming even more attention. Pneumatic surge chambers may be incorporated near the lower end of the hose, probably in the reception coupling itself.

Surge during closure of individual receiver tanks is avoided by the design of the fuel level control valve which closes slowly enough to prevent appreciable fluid deceleration.

● ● Hose Reel

The amount of equipment in a hose reel unit amazes most engineers, but an explanation of the operating requirements and remote control features usually reverses the impression. One can appreciate the extent of future engineering requirements when told that most of the present requirements are being supplemented or replaced by more stringent requirements in future equipment.

One of the hose reel units now in production has operating requirements listed, in part, below. This is the model A-12B-1 and some of its characteristics may give an idea of the nature of the equipment.

- 1) Upon contact of the receiver with the drogue and reception coupling at a relative speed of 3.4 fps, the hose reel must maintain sufficient tension in the hose to avoid damaging slack.
- 2) The hose must be kept under adequate tension regardless of the relative motion of tanker and receiver.
- 3) Braking means must be available to operate on the signal of an angular velocity signal from a governor. (Required in the event of excessive trail speed when the hose is let out into refueling position).
- 4) The fuel valve must open and shut automatically at prescribed intervals of hose trail length.
- 5) A fuel seal on the axis of rotation of the reel must operate with zero leakage and must withstand the pressures associated with high rates of flow.
- 6) The hose reel must introduce less than 40 psi pressure drop during 110 percent maximum flow conditions.
- 7) At the end of the trail, the reel must lock against further outward motion of the hose and become ready immediately for receiver contact.
- 8) Motor control elements must be capable of handling 400 amperes, 28 volts d-c.
- 9) Receiver pilot must receive a visible indication of (a) tanker ready, (b) fuel flowing and (c) emergency wave-off.
- 10) In moving onto the reel, the hose must be guided to prevent overlapping or crushing.
- 11) Equipment must operate satisfactorily between the limits of -65°F and 160°F and at altitudes up to 30,000 feet.
- 12) The design must contain adequate safety features in addition to the basic requirements of structural strength and operating reliability.

Each of the above operating requirements is incidental to the basic function of keeping the hose under tension. The system that has been developed and qualified for use in current equipment consists of a 28 volt d-c motor running at essentially constant speed, coupled to the hose reel through a fluid coupling and a two-speed gear box. The fluid level in the coupling is adjustable remotely so that the torque may be set to provide maximum wind-in rate on contact.

While the electric motor-fluid coupling drive system provides adequate reel response for present operations, new drive systems are being studied. As the parameters of flow rate and flight speed are extended upward, drive system power and weight requirements exceed acceptable levels. The trend toward hydraulic power has been suggested by the reduction in component weight and reduction in complexity of controls that can be achieved. Smooth and adequate reel response to the relative motion of tanker and receiver is a critical feature that must be maintained in spite of changes in the basic drive system. With this as the primary goal of new drive systems under consideration, an analysis of the reel response has been made to determine the ability of proposed hydraulic drive systems for maintaining adequate and stable hose tension conditions. This analysis included analog computer studies conducted to provide data on the magnitude of certain design variables to insure ade-

quacy of the above operating requirements and the remote control features described below, the design is based on the assumed application of very realistic loads and pressures to the hose reels. These load conditions form the basis of the stress analysis to which each part and assembly is subjected to determine the adequacy of the design. A few of the figures pertinent to the model A-12B-1 are used for illustration.

- 1) Design must assume the application of specified flight g loads (8.8 g maximum) and vibration conditions up to 5 g over a wide range of frequencies.
- 2) Operating load applied by hose: 2200 pounds with the reel supporting members designed to withstand 4500 pounds hose pull.
- 3) The fuel passages and seals must withstand operating, proof and burst pressures of 75, 150 and 250 psi respectively.
- 4) The entire hose reel unit must weigh less than 600 pounds dry and must have an operating life of 500 hours or more.

A further basic requirement of the hose reel and fuel transfer equipment is that it be remotely operated with a minimum of control elements. The essential controls plus several indicating meters and lamps and emergency switches are incorporated into a single control panel, but only a fraction of the control panel features are really essential to the routine operation of the equipment. Most of the features are for opera-

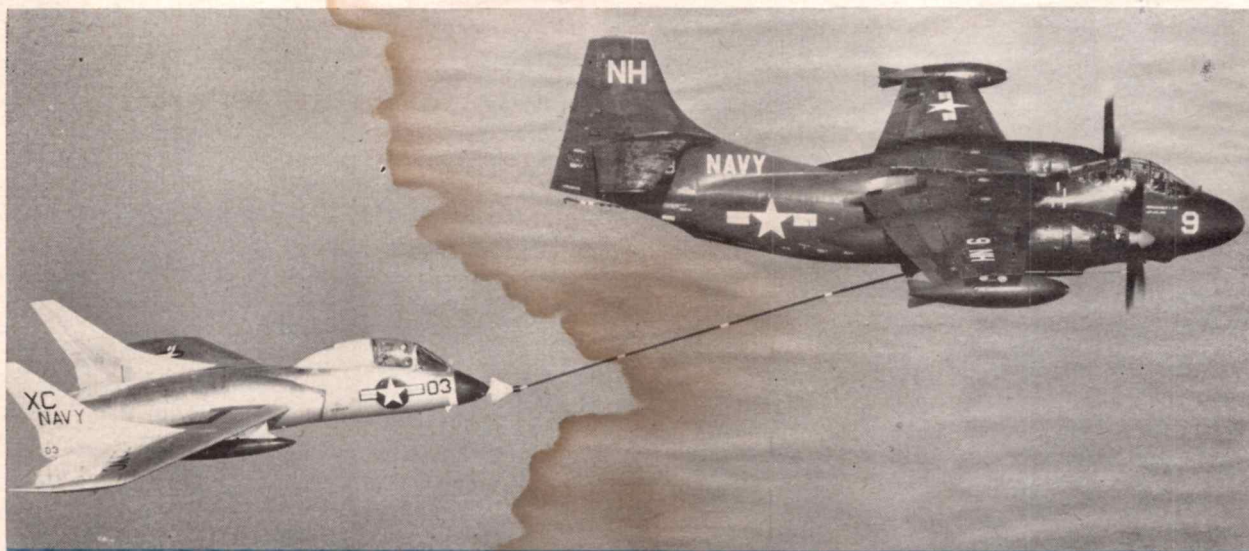


Figure 1—Probe and drogue system used by the Navy for aerial refueling. Navy's standard tanker, the AJ-2 is filling the Cutlass F7U-3.

quate reel response with minimum hunting of the reel drive mechanism. The effect of such variables as hose stiffness, spring constant and damping of pressure sensing and control members, volume of fluid under compression, reel inertia and others were studied for several control systems. The values determined have been applied to specific power system designs, for which stable operation is requisite.

To accommodate the functions expressed in the

tor convenience for emergency operation. The basic controls are:

- 1) A master switch.
- 2) A hose-in-hose-out switch that lets the hose out to start the sequence of operations, which places the drogue in the trailed, refueling position.
- 3) A torque control dial to adjust remotely the scoop setting (amount of fluid) in the fluid coupling and, thereby, the torque transmitted

Refueling

from motor to reel. This is set so that, with the drogue at the end of trail, the force applied to the hose is just under the amount necessary to retract the hose and drogue. Thus maximum hose pull will be immediately available to draw in the hose without whipping when the receiver aircraft makes contact. This torque control dial can be calibrated in flight-speed since flight speed and drogue drag are directly related; thus no adjustment will be required for routine operation.

To assist the refueling equipment operator, there are various other features such as an indication of feet of hose trailed, motor current, fuel valve position

and condition of fluid coupling temperature. In addition, on the left side of the panel are circuit breakers and reset buttons easily accessible in case of a temporary overload in part of the system.

Across the top of the panel are several emergency controls, plus a routine control for placing the equipment in parked condition after landing.

The remote-control automatic operation feature of the probe and drogue system permits use of the system over a broad range of applications. The equipment can be placed in an unpressurized, exposed section. The remote control can be performed by personnel with little specific training. Neither of these advantages has been gained without considerable effort spent toward making equipment capable of withstanding the stringent environmental conditions imposed by exposed, remote control operation. The result is a high standard that has been outlined for the design

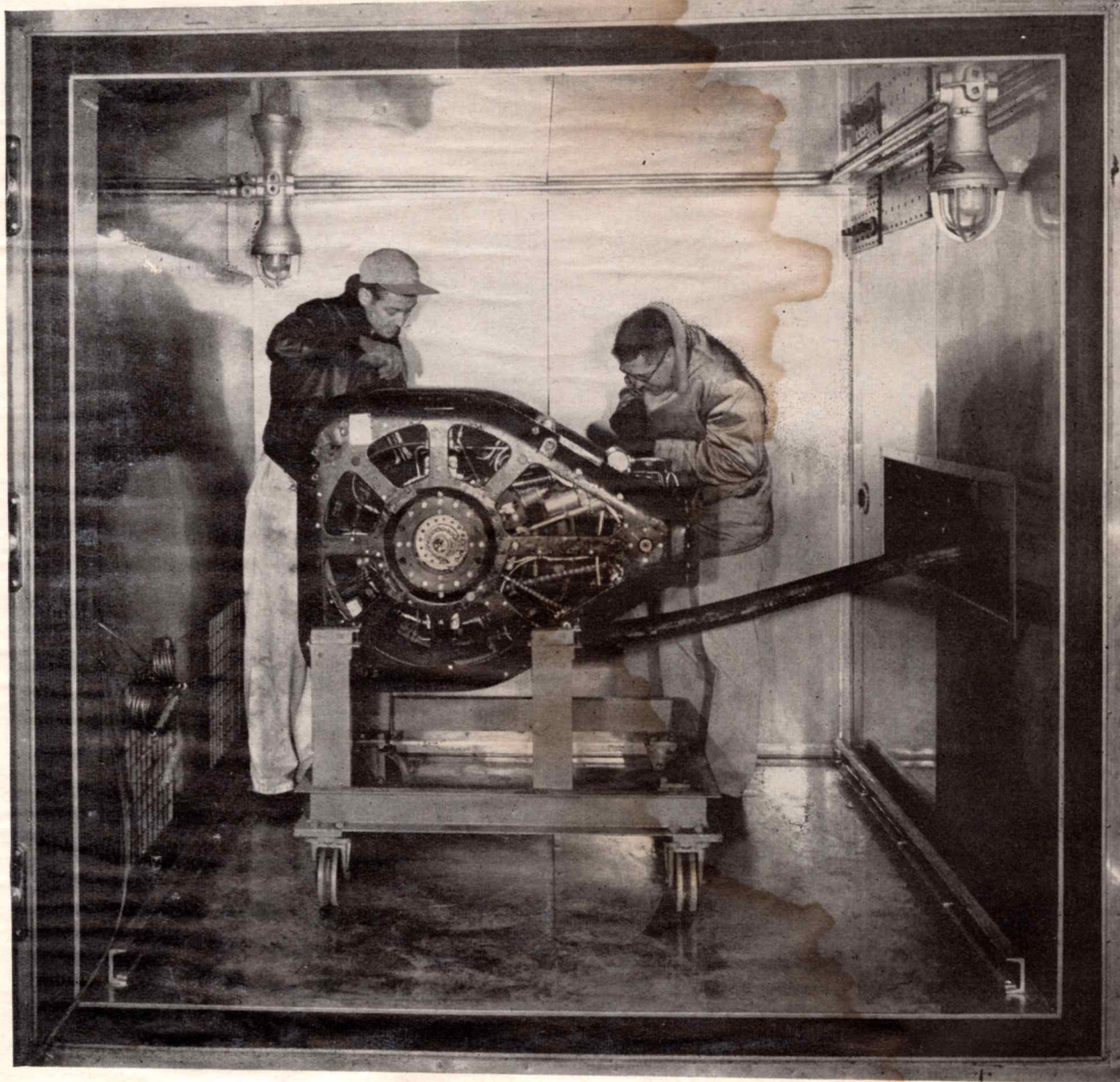


Figure 2—A probe and drogue hose reel unit is readied for a test in environmental chamber at Flight Refueling, Inc. Operation of unit can be studied at temperatures ranging from 100 to 200°F, and at humidities ranging from 20 to 100 percent.

and test of the equipment in USAF General Specification MIL-R-9126 and in the model Specification FRI-1080 relating to the particular equipment involved. These specifications support the theory of thorough ground test prior to flight operations.

The specific requirement for the probe and drogue system is the suspension of a stable aiming point in the air at a suitable location with respect to the tanker aircraft and connected to the tanker with a fuel passage member. This flying receptacle and hose are the most critical parts of the system.

● ● Trailing Members

For equipment now in use, the hose and drogue combined constitute the aerodynamic element. In its conventional form this element has served adequately at flight speeds associated with propeller driven aircraft. As speeds increase and as improvements are made in the refueling operation, it is likely that the nature of the aerodynamic element will change considerably. In an effort to establish what design changes are required, theoretical studies, supplemented by flight testing, are providing valuable information for establishing future design requirements. The problems posed have to do with the dynamic characteristics of the drogue and hose and the stresses applied by higher flight speeds. The answers to these problems will suggest configurations and materials applicable to future aerial refueling equipment.

While analysis of the dynamic behavior of the hose and drogue continues, current improvements are being made in the construction of the hose designated for equipment in production. The essential requirements of this hose are as follows:

- 1) High tensile strength and fatigue strength.
- 2) High crush resistance to allow winding onto tensioning reel.
- 3) Adequate bore size and smoothness.
- 4) Resistance to abrasion and other damage in ground handling.
- 5) Light weight.
- 6) Minimum bend radius.

Until recently, the aerial refueling hose consisted of a rubber inner liner reinforced with a steel spiral located around the outside of the liner and interwoven with a yarn of cotton, nylon, dacron or other fiber. During the past year other hose types have been manufactured and flight tested that appear to have superior characteristics. From the inside diameter out, the construction of one of these types consists of (a) a $2\frac{1}{8}$ inch inside diameter fuel resistant rubber liner, (b) wire reinforcement for crush resistance and strength in tension and (c) an outer cover of rubber for abrasion resistance. The new hose construction weighs somewhat more than the previous hose but has the principal advantages of greater tensile strength and greater resistance to abrasion in handling. The equivalent modulus of elasticity of the newer hose is much greater than that of the earlier hose. While this increase in modulus may decrease the characteristic ability of the hose to absorb surge pressure shock, this potential disadvantage appears to be more than offset by the improvement in other qualities of

the hose. And the surge problem is yielding to other methods of solution.

● ● The Drogue

The most apparent function of the drogue, Figure 4, is to serve as a centering device for the refueling nozzle of the receiver. In the past, a 32 inch diameter has been conventional although drogues with much smaller diameters have been flown into successfully. An equally important function of the drogue is as a tensioning and stabilizing shape for the hose. The drogue's shape dampens radial oscillations of the hose and drogue and the drag of the drogue pretensions the hose.

For present operating speeds the conventional cone type drogue serves satisfactorily provided the refueling unit is disposed in a favorable position with respect to aircraft wake. With refueling flight speeds and altitudes increasing, the drogue design is receiving considerable attention in terms of drogue and hose stability and the effects of drogue wake on the receiver aircraft.

● ● Coupling Members

The ease and reliability of the mechanical refueling contact are determined by the coupling members. To the receiver pilot they constitute the business end of the system. Malfunction of the connection could contaminate his windshield with fuel or subject other parts of his aircraft (including engine intakes) to fuel spray or vapor, not to mention aborting the refueling mission.

The nozzle and coupling members involved in making and maintaining refueling contact must meet certain fundamental requirements to achieve the proper degree of reliability:

- 1) They must withstand forces applied by 10 fps relative contact speed. This subjects both members to high forces due to acceleration and drogue drag.
- 2) Coupling must be made and broken on completion of refueling with minimum leakage (25 cc or less).
- 3) Engagement must require less than 140 pounds. When in contact, however, 300 to 800 pounds are required to break the connection.
- 4) For certain applications, the force required to disengage must increase during fuel flow as an added safety measure.
- 5) Pressure drop across engaged members must be only a few psi for hundreds of gallons per minute.
- 6) Design must allow successful engagement with large angular offset approach.
- 7) Weight requirements: coupling, 20 pounds maximum; nozzle (less supporting mast), 5 pounds maximum.

Several types of nozzle and coupling combinations have been developed and put into service and new designs are being tested at the present time. All are based on the fundamental requirement that the engagement must seal peripherally prior to action of the valve members and that further motion of the engagement opens the fuel passage.

Refueling

At the present time, the Navy is using the Model A-3 type coupling with the A-1 type nozzle, and the Air Force is developing and testing the Model MA-2. Both models are currently in production at Flight Refueling, Inc. Other models are being developed in a continuing effort to improve the operating characteristics for standard and for special in-flight refueling applications.

In certain installations it is necessary to equip the receiver aircraft nozzle with anti-icing means. A small, continuous flow of alcohol over the nose of the nozzle has been a successful means of preventing icing and other methods are being studied.

● ● Receiver Aircraft Equipment

The principal considerations applicable to fitting a receiver aircraft are (a) the location of the probe and (b) the fuel system modifications that may be required to accommodate single point refueling. The following factors are considered when choosing the location and designing the installation:

- 1) Pilot visibility for probe-drogue contact.
- 2) Location of receiver aircraft control surfaces that might be affected by drogue wake.
- 3) Possibility of contaminating windshield in the event of spillage, especially if fuel is one of the JP variety which does not evaporate readily.
- 4) Structural modification required in the aircraft for mounting of the probe.
- 5) Proximity and accessibility of probe to fuel tanks or fuel lines. It is not unusual to find that the most desirable location may be barred by the location of guns, cameras, radar and other equipment.
- 6) Relative location of engine air intakes.

The greatest number of contacts to date has been made with the probe located in the nose of a wingtip tank. There is a trend away from wing locations to nose locations, which is the most advantageous from the point of view of pilot visibility. In the future this location should be made more readily available since allowance is being made in the original aircraft design for probe installation.

Pressure refueling systems have become common to military aircraft, which facilitates ground as well as flight refueling operations. The several tanks to be filled are joined to the probe mast through a manifold. In the initial phases of the refueling operation, a controlled 50 psi at the nozzle will insure the maximum flow since all tanks will be opened. As each tank shuts down by the duplicated action of two level control valves or switches, the total flow will decrease due to the tanker pressure control system. An attempt has been made in the design of aerial refueling systems to keep the equipment in the receiver to an absolute minimum in weight and complexity.

The total weight penalty in most current fighters equipped with manifold, pressurized refueling systems is 15 to 25 pounds. Without such a refueling system

this weight penalty is approximately 100 pounds including nozzle, probe mast structural additions and fuel system modifications.

● ● Ground Testing

Although experience by the US Air Force with the early British probe and drogue equipment was successful in proving the principle of operation, certain failures in operation proved the necessity of adequate ground testing which had not been performed prior to these earlier probe and drogue trials. In collaboration with the Air Force, Flight Refueling, Inc., established a complete test facility in 1954 whereby equipment could be flight tested on the ground under actual fuel flow conditions.

The test program outlined for the qualification of a hose reel unit shows where the emphasis should lie. Reliability evidence may be further established by proving the attainment of additional design aims:

- 1) Endurance Tests: The equipment shall be tested through 500 complete cycles with appropriate forces applied through the hose during trail, re-wind and disengagement. During these tests, rated pressure shall be maintained in the fuel passages with no evidence of leakage or malfunction.
- 2) Vibration Test: (Procedure I, MIL-E-5272) This includes, for each of the three directions at 5 g maximum acceleration: (a) one hour of cycling between 10 and 55 cps at a double amplitude of 0.036 inches and (b) three hours of vibration at resonant frequencies between 10 and 500 cps.
- 3) Low Temperature Test: After a cold soak at -65°F for at least 72 hours, the unit shall operate satisfactorily through ten normal cycles.
- 4) Humidity Test: (Procedure I, MIL-E-5272) 360 hours of cycling between ambient temperature and 160°F at 95 percent relative humidity.
- 5) Salt Spray: The assembly is subjected to 50 hours continuous salt spray.
- 6) Structural Loading, Reel Response, Pressure Loss and Proof Pressure: Test evidence is

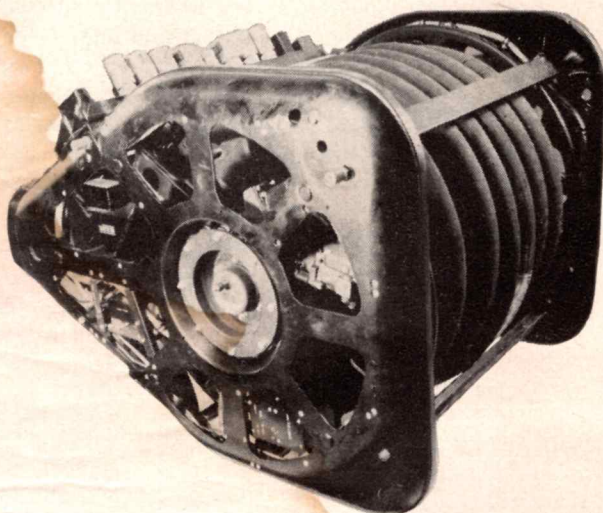


Figure 3—A-12 hose reel, standard refueling unit used in the North American AJ tanker.



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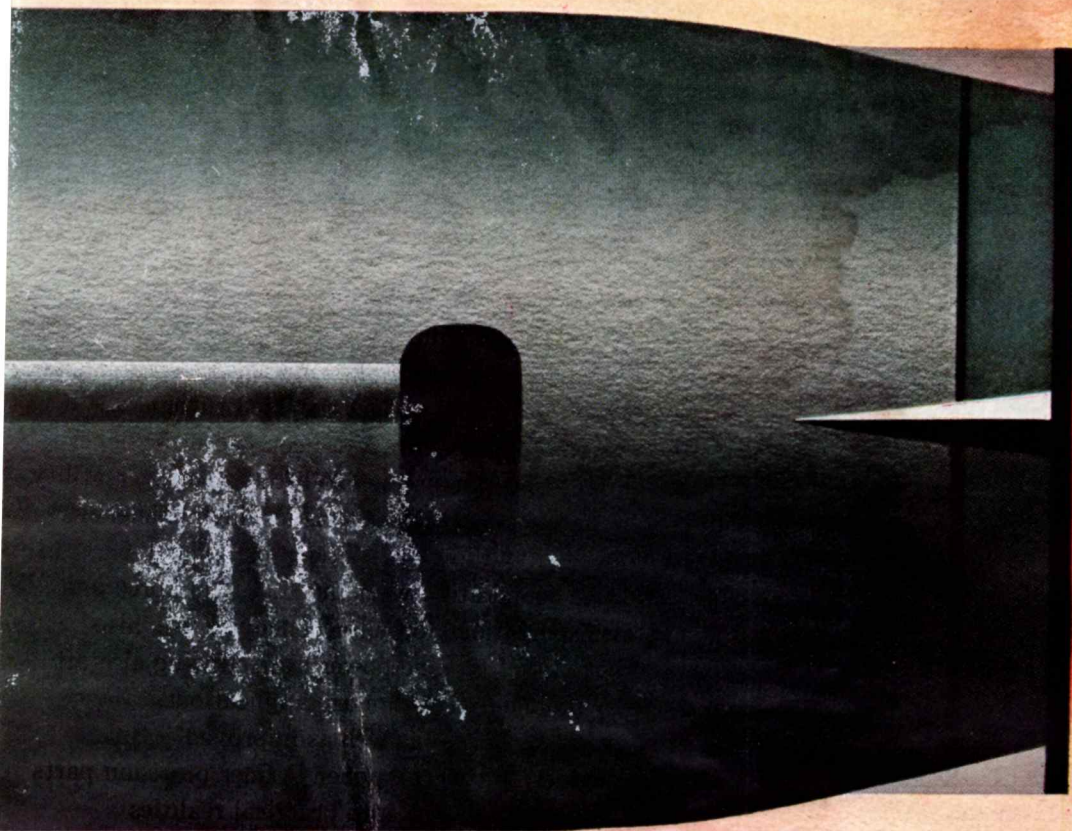
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obtained for each of these characteristics to insure that design aims have been met.

After these tests, the operation, disassembly and inspection must give evidence that none of the above tests have produced deterioration, deformation, malfunction or undue wear. The tests are performed on prototypes of the production articles and each unit in production is subjected to fuel pressure and functional testing prior to shipment.

• • Advanced Tanker Applications

The tanker refueling mission in future operations will be accomplished at speeds and altitudes associated with advanced aircraft. This places new demands on the refueling system. The improved environmental characteristics of the components associated with the refueling equipment must also be accompanied by improvements in hose tension control, structural loading qualities and flow rate.

Coincident with required advances in the operating characteristics is the desire for further versatility in a design that can permit installation in low drag, wing mounted pods as well as in the fuselage. Although pod installations have been successfully used in the past, reduction in frontal area and other improvements will permit lower drag and a simpler installation.

An idea of the range of considerations that must be made is given by a sampling of design information required for the application of refueling equipment to a specific aircraft:

- 1) Tanker and receiver flight performance envelope with and without external stores including the variation of indicated air speed or Mach number with altitude at various gross weights and power settings.
- 2) Data on fuel systems of tanker and receiver including fuel consumption, fuel flow controls, and mechanical details of tanks and passages.
- 3) Wing area, airfoil section, incidence, aspect ratio, angle of sweepback and location and nature of tanker and receiver control surfaces.
- 4) Maximum tolerable aerodynamic moments that can be allowed by refueling gear.
- 5) Stability data in pitch, yaw and roll based on wind tunnel data showing the variation of force and moment coefficients with various Mach numbers.
- 6) Engine wake charts showing wake velocity and temperature distribution under various conditions of altitude, air speed and thrust.
- 7) Type and level of power (electrical, hydraulic, pneumatic) available from tanker aircraft.
- 8) Details of construction at potential mounting locations of refueling equipment.

With this type information, which would also include other aerodynamic and mechanical data, the design can proceed with proper consideration given to all aspects.

Before specific design values can be established for a given application based on the above type of information, considerable research and development is

required to provide basic data to support all such programs. Some of the area where unknowns exist and engineering work is being conducted are:

- 1) Surge suppression and prevention at high flow rates.
- 2) The aerodynamic characteristics of the trailing members at higher flight speeds.
- 3) Ability of aircraft to achieve close formation coupling.
- 4) The aerodynamic influence of the receiver on the tanker and vice-versa in close formation coupling including aircraft stability and control considerations.



Figure 4—Standard refueling drogue manufactured by Flight Refueling Inc. is 32 inches in diameter and made of aluminum. Two small cylinders near narrow end of drogue contain lights for night refueling.

- 5) Provision of safety features required by formation coupling.
- 6) Improvements in rendezvous and refueling contact under heavy weather conditions.

Further assistance to the designer of the refueling equipment will be provided by a factor that has heretofore been rare: more and more new aircraft will be engineered with the aerial refueling capability as a design criterion and not as an expedient added after the design basis and details are committed. END

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Fatigue failures of actuating-cylinder rod ends on control booster systems can be minimized by appropriate placing of lubrication holes, by designing rod ends as thick as available bearings allow, and by adequate torquing of rod-end lock nut.

DESIGNING ROD ENDS for Fatigue Strength

By G. D. LINDENEAU, Test Engineer, Convair (San Diego)

A Division of General Dynamics Corp.

IN HIGH SPEED AIRCRAFT, control-booster systems are subjected to high, frequently changing loads. Therefore, satisfactory fatigue strength of the systems' components is essential.

The component under consideration is the actuating-cylinder rod end. A series of fatigue tests recently completed on rod ends with spherical bearings indicated that more emphasis should have been placed on the fatigue design. Primarily the tests were run to qualify the rod ends for given number of cycles at cylinder operating pressure loads. Early failures in some cases caused the tests to be expanded to obtain design information for future rod ends. The results of these tests are shown in Table I; photographs of test specimens are shown in Figure 1.

● ● Designing Against Failures

A summary of the test results shows that there were three typical failure points (Figure 2).

21 of 35 failed at Point No. 1.

11 of 35 failed at Point No. 2.

3 of 35 failed at Point No. 3.

There were 46 rod ends tested, of which 35 were tested to failure.

With respect to failures taking place at Point No.

1, a substantial increase in fatigue life could have been obtained with a slight design change. The first suggestion would be to move the lubrication hole (17 of 21 failures occurred at this point) to another location on the rod end, preferably to the upper end of the rod end within 45 degrees of the longitudinal centerline. If this is not possible because of accessibility or clearance considerations, then a boss should be provided for the lubrication hole. This suggestion was incorporated in rod end B which had a 300 percent increase in minimum fatigue life over rod end A. This design change required a slight increase in weight and additional machining operations; but in view of the substantial fatigue life increase, the additional weight and cost was considered advisable.

Failures at Point No. 1 could probably be avoided by some configuration in this area, but there is a lack of stress concentration data for shapes of this type. A reversal of external load probably does not cause a stress reversal at this point; but the proportion of compression to tension stress is not known to the writer.

There are several ways to increase the fatigue life of a rod end at the threads, Point No. 2. Normally the failure occurs at the first engaged thread. The lock

Table I Fatigue Test Results

Type Rod End	Axial Load (lb)		Test Machine*	Fatigue Life (group average)	Remarks
	Min.	Max.			
A	-100	-13,000	SF 20U	101,300	Failure at Point No. 1, 3 specimens, Lubrication hole
B	-100	-13,000	SF 20U	381,000	Failure at Point No. 3, 3 specimens
C	-21,196	-18,537	SF 10U**	5250	Failure at Point No. 1, 4 specimens, Lubrication hole
D	-13,520	-9600	SF 20U	17,750	Failure at Point No. 1, 4 specimens, Lubrication hole
E	-19,250	-10,550	SF 10U**	8000	Failure at Point No. 1, 2 specimens, Failure at Point No. 2, 2 specimens
F	-8875	-8875	SF 20U	16,750	Failure at Point No. 1, 4 specimens, Lubrication hole
G	-8180	-4860	SF 20U	69,250	Failure at Point No. 2, 4 specimens
H	-21,196	-18,537	SF 20U**	32,500	No failure, Test discontinued, 2 specimens
I	-2375	-1885	SF 1U**	219,000	Failure at Point No. 1, 1 specimen, No lubrication hole
J	-5750	-3095	SF 20U	210,000	Failure at Point No. 2, 2 specimens
K	-9430	-7070	SF 10U	126,000	Failure at Point No. 1, 3 specimens, Failure at Point No. 2, 1 specimen
L	-3283	-3490	SF 20U	227,500	Failure at Point No. 2, 2 specimens

* SF 20U—Sonntag—20,000 lb, SF 10U—Sonntag—10,000 lb, SF 1U—Sonntag—2000 lb

** With load amplifier

nut should be torqued up to put an initial tension stress in the threads, Reference 1. If a stress higher than the operating stress is induced by the nut torque then the threads are subjected only to a relatively small stress change by the operating loads on the rod end. This implies that the fatigue life of threads could then be infinite. In practice this ideal condition probably does not exist: either the initial torque is not high enough or the lock nut will loosen in service and thread failures will occur. A rolled thread will have an increased fatigue life over a machined or ground thread. The rolling operation, for the best effect, should be a final sizing after machining and heat treatment. Some beneficial effect can be had by rolling the thread roots only. A very large increase in thread fatigue life can be had, of course, by changing to a larger major diameter thread size. Reference 2 shows the fatigue concentration factors for various types of threads.

The failures at Point No. 3 can be minimized by changing the dimensions of the sections adjacent to the bearing without changing the net area. This area of the rod end is similar to a pin loaded lug for which concentration factors may be found in References 2, 3 and 4. An examination of the charts in these references shows that the concentration factors may be reduced by decreasing the width and increasing the thickness of the section. If these dimensional changes are made in the correct proportion, the area remains the same with the same static strength but with increased fatigue life at this point. Some increase in fatigue life at this point can possibly be obtained by pressing in the bearing with a greater interference fit. This operation, as with torquing up the lock nut on the threads, will put initial stresses around the hole which should have a beneficial effect. The limitation on this method is that bearing binding occurs if the

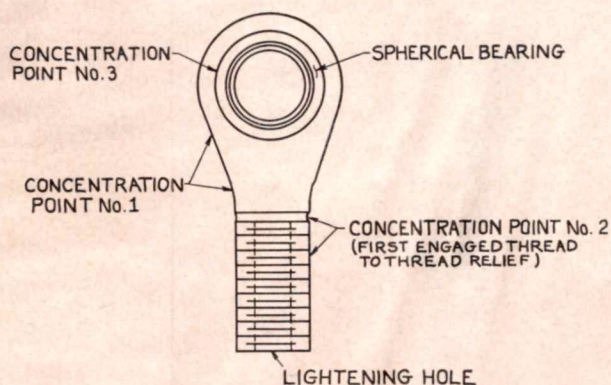


Figure 2—Typical location of concentration points.

bearing manufacturers' installation fits are not adhered to. Design suggestions are as follows:

1. Avoid placing a lubrication hole at Point No. 1 unless a boss is added. A better location would be at the upper end of the rod end within 45 degrees of the longitudinal centerline.
2. Design the rod end as thick as available bearings allow, and minimize the width adjacent to bearing for the minimum concentration factor at Point No. 3.
3. Require that a substantial torque be used on the rod-end lock nut and a frequent torque check be made for best fatigue life of threads. END

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3. Peterson, R. E., *Stress Concentration Design Factors*, John Wiley & Sons, 1953.
4. Timoshenko, S., *Theory of Elasticity*, McGraw-Hill Book Co. Inc., 1934.

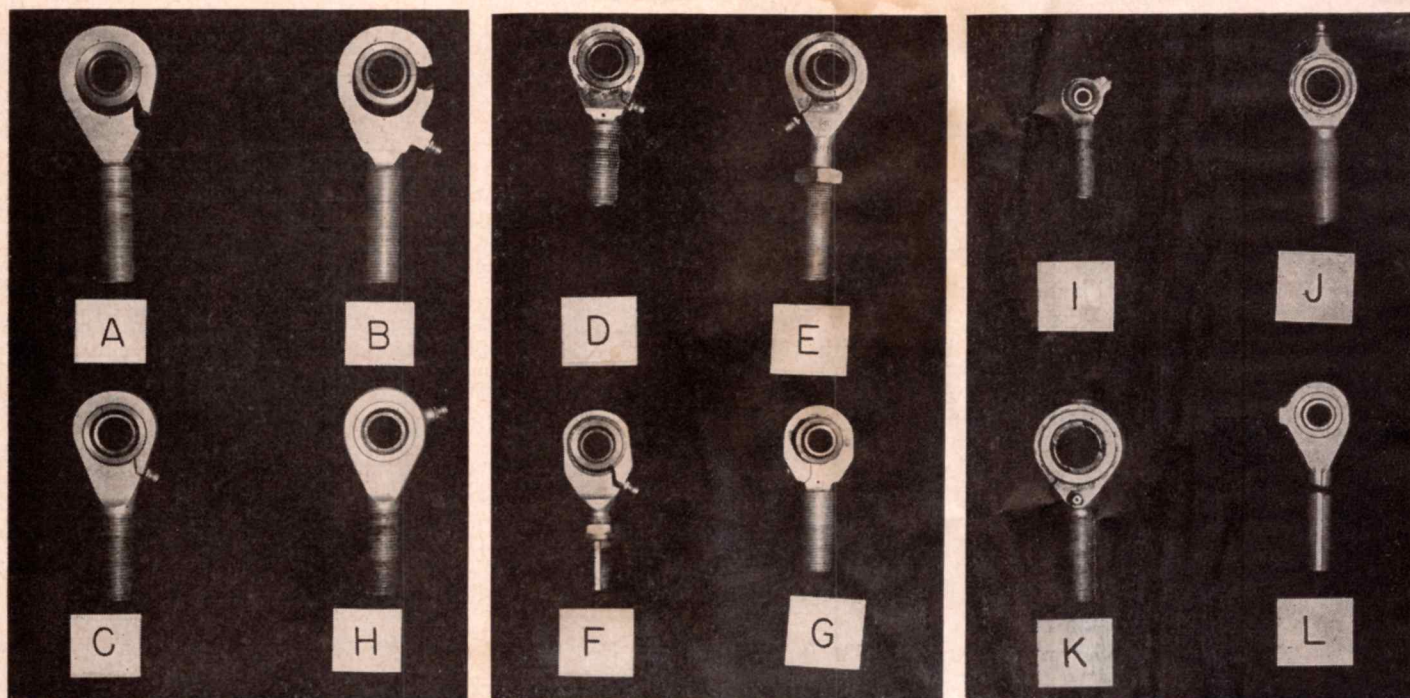
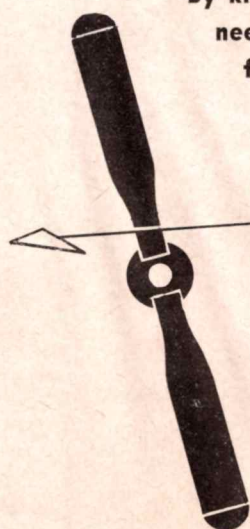


Figure 1—Rod ends used in fatigue tests.

By knowing diameter, type wing flap to be used, and two simple parameters, engineer is able to learn take-off run in a few minutes. Method is sufficiently accurate for early design work, and applies to conventional aircraft having usual proportions and drag characteristics.



SIMPLIFIED METHOD FOR PREDICTING TAKE-OFF PERFORMANCE OF PROPELLERED AIRCRAFT

By **KEN S. COWARD**, Vice President, Engineering, Bee Aviation Associates, Inc.

FOR PRELIMINARY DESIGN WORK, where time and data are short for predicting take-off performance of propellered aircraft by the classical methods, the designer can use the following procedure which gives reasonable accuracy. It is necessary to know only the propeller diameter, the type wing flap used, and two basic parameters, namely, wing loading and power loading.

In addition to predicting take-off performance in the early design stages, the method also shows the effect of the following changes on a proposed aircraft design:

- 1) Changing gross weight,
- 2) Changing the powerplant, or simply changing power,
- 3) Changing propellers,
- 4) Changing altitude,
- 5) Changing the wing flap characteristics.

● ● Examples

Ground run distance is found directly from curves, as follows:

Example 1:

Find the ground run distance for the airplane whose $W = 800$ lb, $S = 100$ ft², $P = 65$ bhp, $D = 6$ ft, at sea level and with no wing flaps.

Calculate $P/D = 65/6 = 10.8$. Now from Fig. 1, find $k_1 = 5.5$. Compute $W/S = 800/100 = 8.0$; $W/P = 800/65 = 12.3$; and $(W/P)/k_1 = 2.24$.

Enter Fig. 2 with $W/S = 8.0$, proceed up to curve $(W/P)k_1 = 2.24$, and read ground run distance as 270 ft.

Example 2:

Find the ground run distance for the airplane whose $W = 2700$ lb, $S = 178$ ft², $P = 205$ bhp, $D = 7.33$ ft, at 2500 ft altitude and with plain flaps.

From Fig. 5, for altitude = 2500 ft, $k_4 = 1.09$. Also, $W/S = 15.2$, $W/P = 13.2$, $P/D = 28$. Now, from Fig. 1, $k_1 = 5.2$; from Fig. 5, $k_2 = 1.08$. Thus,

Symbols

C_{L_m}	= maximum lift coefficient
C_{D_o}	= minimum drag coefficient = f/s
C_P	= propeller power coefficient
C_T	= propeller thrust coefficient
D	= propeller diameter, ft
D'	= airplane drag, lb
f	= airplane equivalent flat plate area, ft ²
g	= acceleration of gravity, ft/sec ²
k_1, k_2, k_3, k_4	= parameters
μ	= coefficient of rolling friction
P	= airplane total rated horsepower used for take-off
q	= dynamic pressure, lb/ft ²
R/C	= rate of climb, ft/min
S	= total wing area, ft ²
S'	= ground run distance, ft
σ	= density ratio
T	= thrust, lb
V	= take-off speed
V_s	= stall speed
W	= airplane gross weight, lb

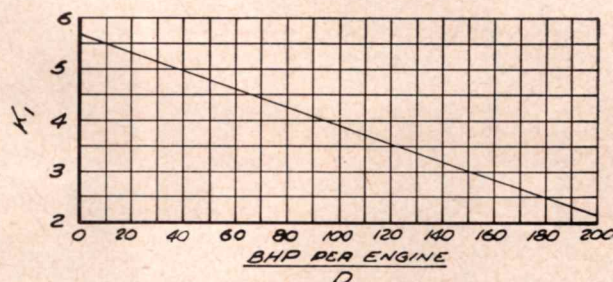


Figure 1—Parameter curve.

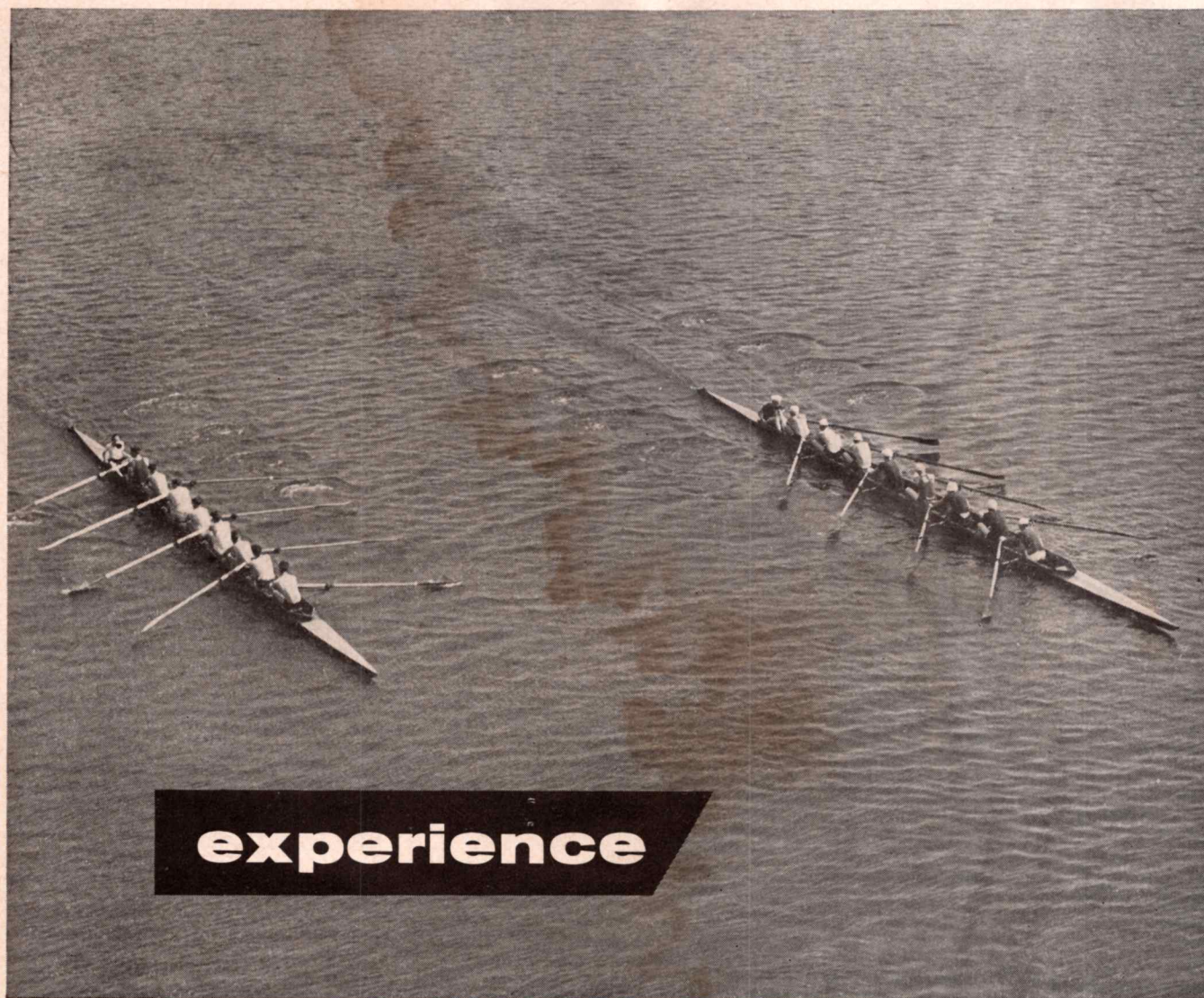
$$(W/P)' = (W/P)k_1 = (13.2)(1.09) = 14.4,$$

$$(W/S)' = (W/S)k_2 = (15.2)(1.08) = 16.4,$$

and

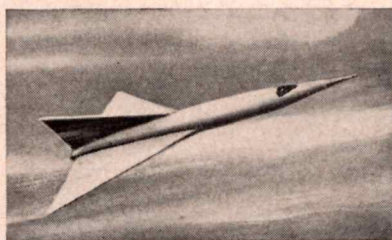
$$(W/P)' / k_1 = 14.4 / 5.2 = 2.77.$$

Enter Fig. 3 with $(W/S)' = 16.4$, and proceed up to $(W/P)' / k_1 = 2.77$, and read ground run distance = 570 ft.



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For further information circle Reader Reply No. 30

Ground distance traversed by the aircraft while airborne, from take-off point to point over 50 ft obstacle, is found from:

$$\begin{aligned}\text{Distance} &= \frac{85,400 k_3 \sqrt{W/S}}{R/C}, \text{ for no flaps,} \\ &= \frac{78,000 k_3 \sqrt{W/S}}{R/C}, \text{ for plain flaps,} \\ &= \frac{72,100 k_3 \sqrt{W/S}}{R/C}, \text{ for fowler flaps.}\end{aligned}$$

In these expressions, k_3 is found from Fig. 5; rate-of-climb (R/C), if not known, is found from *Reference*. Thus, for Example 1,

$$\text{Distance} = \frac{85,400 (1.0) \sqrt{8}}{1000} = 242 \text{ ft.}$$

Total distance traversed equals ground run of 270 ft plus airborne distance of 242 ft to point over 50 ft obstacle, which yields a total distance from start of ground run of 512 ft.

● ● Assumptions

By using these curves, the engineer makes the following assumptions:

- 1) Take-off is made at 1.2 times the stall speed. Flaps are set at take-off deflection.
- 2) Runway is hard, such as asphalt or concrete paving.
- 3) Take-off power is applied while pilot holds aircraft with brakes; then he releases brakes to start take-off roll.
- 4) Wind is zero.
- 5) Runway is level.
- 6) Standard day temperature exists.

● ● Derivation

Curves are based on the following demonstration:

Kinetic energy at take-off = take-off distance $\times$ average accelerating force,
that is,

$$K. E. = \frac{1}{2} W V^2 / g = S' (T_{.TV} - D'_{.TV} - \mu W) \quad (1)$$

Therefore,

$$S' = k_V W V^2 / 2g (T_{.TV} - D'_{.TV} - \mu W) \quad (2)$$

The factor k_V is used to correlate take-off distance derived from Equation (2) with flight test results. For this purpose, experience indicates that $k_V = 1.1$. Now,

$$\begin{aligned}V &= 1.2 V_s = 1.2 [391 (W/S) / C_{L_m} \sigma]^{1/2} \\ &= 563 (W/S) / C_{L_m} \sigma, \text{ mph}\end{aligned} \quad (3)$$

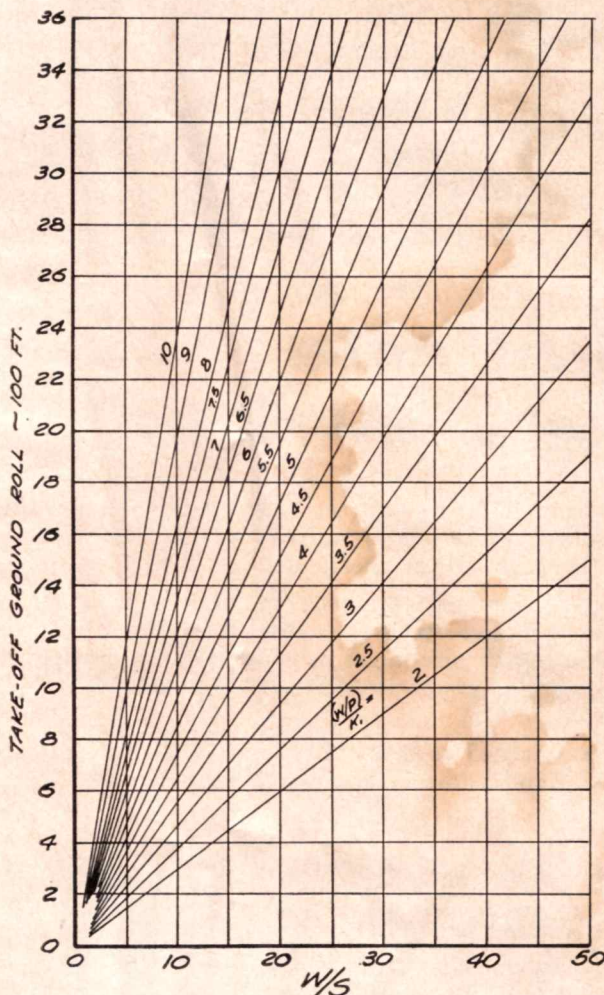


Figure 2—Take-off ground roll (no flaps).

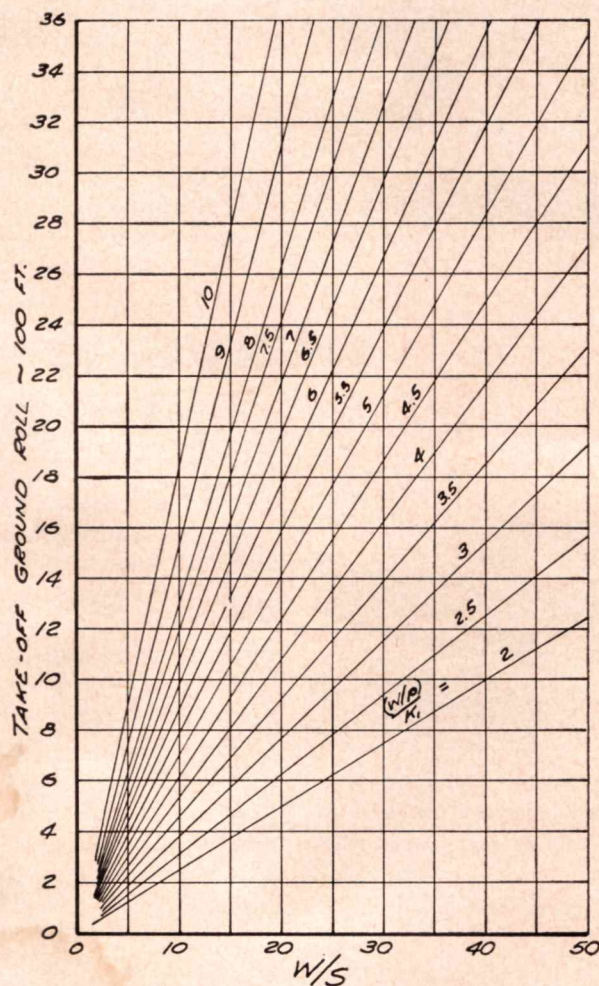


Figure 3—Take-off ground roll (plain flaps).

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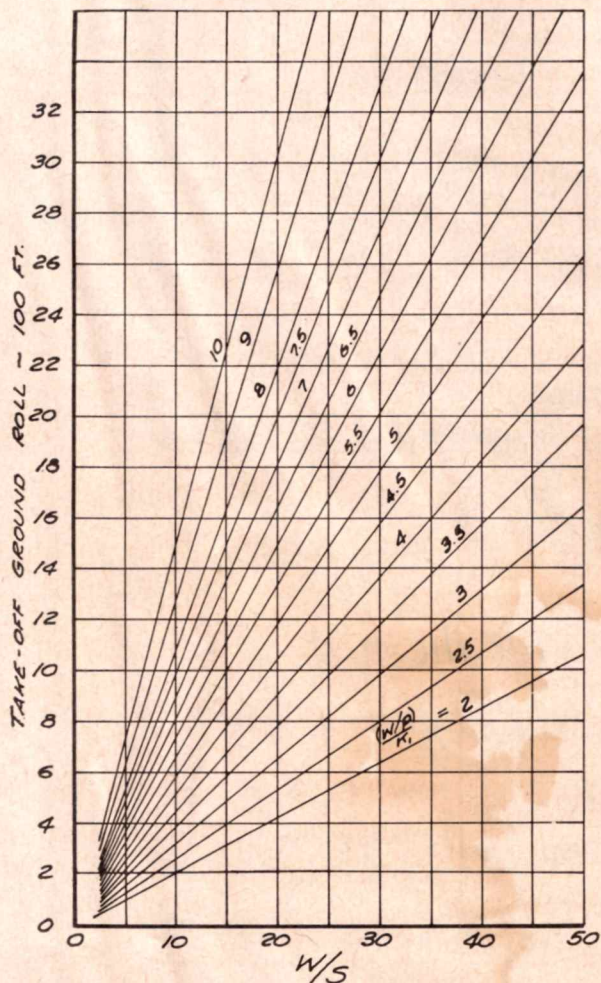


Figure 4—Take-off ground roll (fowler flaps).

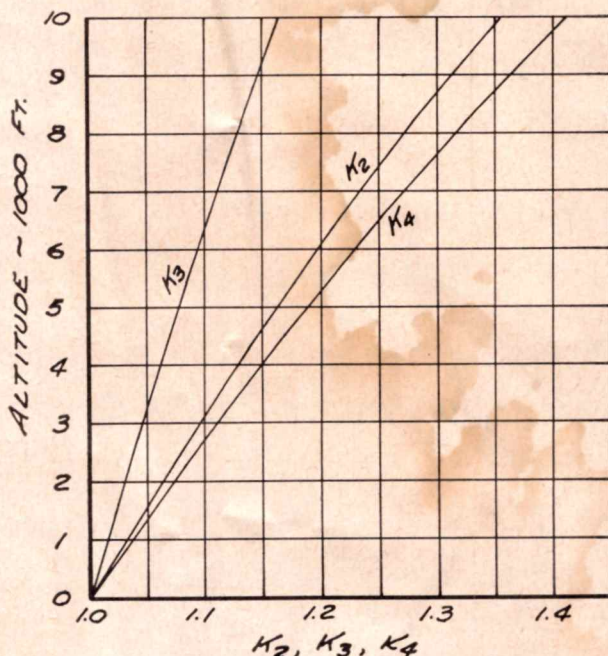


Figure 5—Parameter curves.

Therefore,

$$V^2 = 1210 (W/S) / C_{L_m} \sigma, \text{ ft}^2/\text{sec}^2 \quad (4)$$

If k_4 takes care of altitude effects, then

$$T_{AV} = k_1 P / k_4 \quad (5)$$

Drag effects are small, hence there is only little loss in accuracy if it is assumed that there are no altitude effects in the drag expression. Hence, by use of Equation (3), with $\sigma = 1.0$,

$$\begin{aligned} D'_{AV} &= f q_{AV} = C_D S (0.7V)^2 / 391 \\ &= 0.705 C_D W / C_{L_m} \end{aligned} \quad (6)$$

If the static value of $\mu = 0.04$, take the average effective value of $\mu = 0.02$. Then, substitute Equations (4), (5), and (6) in Equation (2), simplify and get:

$$S' = \frac{20.7 (W/S) / \sigma}{C_{L_m} [k_1 / (W/P) k_4 - 0.705 C_D / C_{L_m} - 0.02]} \quad (7)$$

In the above expression, the induced drag was assumed negligible in view of ground effects.

Equation (7) was plotted in Fig. 2, 3, and 4, where the following values were assumed:

$C_{L_m} = 1.5$ for no flaps, 1.3 for plain flaps, and 2.1 for fowler flaps.

$C_{D_0} = 0.045$ for all flap conditions inasmuch as the gear is down for all planes during take-off. This value has been found to be quite accurate for all airplanes. In addition, the effect of the term involving C_{D_0} is small.

Derivation of formula for distance over 50 ft obstacle is as follows:

$$\frac{\text{Distance}}{50} = 88V / (R/C)$$

Substitution of Equation 3 in above equation yields,

$$\text{Distance} = \frac{104,300 k_3}{R/C} [(W/S) / C_{L_m}]^{3/2}$$

where k_3 is altitude factor. Substitution of appropriate maximum-lift-coefficient values gives the formulas presented earlier.

The k_1 variation shown in Fig. 1 was obtained by examination of experimental take-off data gained from light aircraft and transport aircraft. The idea behind its use rests on the fact that the ratio of thrust to power depends upon the ratio of thrust coefficient to power coefficient (C_T/C_P) dividend by tip Mach number. If it is assumed that most propellers operate at about the same tip Mach number, then the C_T/C_P value varies approximately as bhp/D .

Factor k_2 is simply $1/\sigma$; factor k_3 is $\sqrt{1/\sigma}$; and factor k_4 is the inverse of the variation of full throttle power with altitude, for an unsupercharged engine.

It should be pointed out that the curves presented are valid for conventional aircraft in which the general proportions and drag characteristics are not unusual.

END

Reference

Ken S. Coward, *Simplified Performance Prediction*, p. 28 ff., *Aero Digest*, December 1954.

X | *This is the tenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.*

Chromium and Its Effects in Alloy Steels

As previously pointed out in this series, **the elements** that together make **up an alloy steel** work both singly and collectively. In a sense they **are like** the components of a machine, each having its job to do, yet each working with other components to achieve an overall result.

An earlier discussion was devoted to the functions of nickel. In this one we shall outline briefly some of the purposes of chromium, another of the fundamental alloying elements.

Chromium is a versatile agent. Among other things, it fosters depth-hardenability, improves surface resistance to abrasion and wear, and promotes carburization. Of the common alloying elements, chromium ranks near the top in hardenability. This property tends to make high-chromium steels relatively air-hardening; hence it is valuable in applications where, for one reason or another, liquid quenches are undesirable.

Chromium steels **are relatively** stable at high temperatures and are often used where resistance to heat is important. Moreover, the presence of chromium is a vital factor in helping to retard or prevent corrosion.

The uses of chromium steels are many and varied. Among the more

familiar items that often contain chromium are hand tools, gears, springs, turbine wheels, ball and roller bearings, forged shafts and rotors, etc. There are of course numerous others; **virtually no list** would be all-inclusive.

One of the most useful of the alloys, chromium has been the subject of long study by Bethlehem metallurgists. These technicians have a thorough working knowledge of its effects in various types of analyses. Whenever you have a problem involving chromium steels, or would like to know more about the subject in general, by all means communicate with the Bethlehem staff. Our men will come to your office or plant at any time. You will find them co-operative and helpful.

And please remember, too, that Bethlehem makes the full line of AISI standard steels, as well as special-analysis steels and all carbon grades. Your inquiries will receive our most careful attention.

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British feederliner enters race for DC-3 replacement. Structural economies result from heavily stiffened wing and wide use of spot welding in basic airframe.

Design Analysis of the **HANDLEY PAGE HERALD**

By **R. A. COLE**
Herts, England

EUROPEAN MANUFACTURERS have focused much of their attention on a DC-3 replacement. Naturally, because of technical advances, the newly designed aircraft will have much improved performance and load-carrying capacity. Yet, despite the good performances of the new aircraft, none of the makers have a real clue about the size of the market. This is a problem of great magnitude, particularly if the manufacturers have prototype aircraft flying.

In an effort to overcome this trouble, Handley Page Ltd., Reading, England, carried out a market survey. They asked operators throughout the world for their ideas on feeder line aircraft specifications. The *Herald* is a direct result of the survey, Table 1.

Already the makers claim orders for 29 aircraft coming from three airlines; how many each has ordered is not disclosed, but it is believed that one company will not start operating until its *Heralds* arrive.

The airplane has been designed to carry comprehensive services, yet maintain a simple layout and sturdy structure appropriate to a utility aircraft. A clean looking four engine high-wing monoplane layout, with single fin and rudder, has been developed.

The Frye F. 1 Transport, less sophisticated than the Handley Page Herald, is leaving its drawing boards to enter the DC-3 replacement race. Developed by the Frye Corp., Fort Worth, Texas, the proposed aircraft has a design cruising speed of 150 mph, normal cruising altitude 12,000 feet, four 600-hp P&W Wasp engines, and an 8000-10,000 pound payload.

Developers of the Frye F. 1 say their craft is not intended to compete with the Herald. With a takeoff speed less than 55 mph and range of 250 miles, they see the Frye F. 1 being extensively used for bush hopping in underdeveloped territories, particularly where ground transportation is meager or non-existent.

Nowhere have expensive streamlined shapes been used, Figure 1.

• • Specifications

Cabin pressurization is used, the design working differential being low, 3.55 psi; this is sufficient for long operations around 10,000 feet. No provision for air humidification is made since a partial recirculation air system is used; also, the outside air at such altitudes contributes moisture: every minute, 50 pounds of fresh air enters the cabin.

Temperature tolerance in the cabin ranges from 15 to 21°C at 10,000 feet, with exterior air temperatures ranging from -30°C to intercontinental maximum.

Two standard seat pitches are provided, 34¼ and 38 inches; the seats may be quickly changed from one pitch to the other. All seats and attachment points are stressed to a nine-g deceleration factor. The cabin floor is stressed for freight loads and has numerous lashing points. A large loading door is provided; the gap is 5½ feet wide by 5 feet high, the threshold being a mean 3¾ feet above ground level. A smaller hatch is situated aft of the cockpit bulkhead on the port side. Seats can be folded against the wall or taken right out when the airplane is used for cargo carrying. Maximum seating accommodation is for 44 passengers.

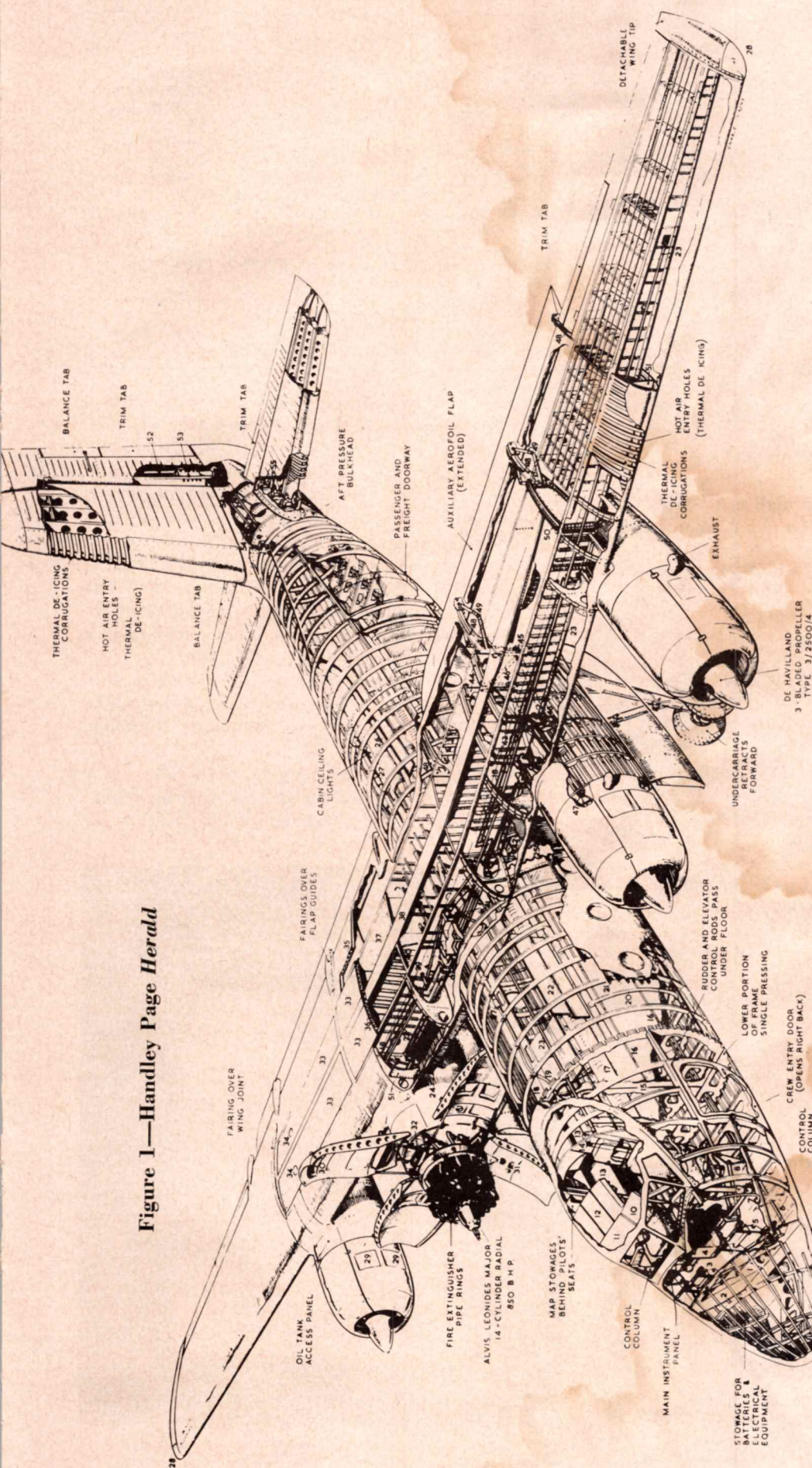
Electrical system consists of a 24 volt supply, taken from three 6-kw d-c generators and a 25 ampere-hour battery; a further 5 ampere-hour battery is provided for emergency use. Inverters give a 115 volt, 400 cycle a-c current for radio and instruments; a similar arrangement also provides a 19 volt supply.

Practically any of the current British and American radio equipment can be fitted in the aircraft. A special arrangement for a radio operator can be made, but normally radio operation is carried out by one of the two pilots. All but one of the numerous radio aerials are built into the structure, thereby eliminating their drag.

A 3000 psi hydraulic system is used for undercarriage, and flap operations. An emergency air bottle is provided in the circuit, together with the usual hydraulic accumulators; but apart from these items, pneumatics are not used on the aircraft.

Fuel valves and pumps are electrically actuated. A

Figure 1—Handley Page Herald



DE HAVILLAND
3-BLADE PROPELLER
TYPE 3/2500/4

1. Interconnecting rod for dual rudder pedals
2. Forward pressure bulkhead
3. 2nd Pilot's rudder pedals
4. Center console—Engine and trim controls
5. 1st Pilot's rudder pedals
6. Rudder control rod
7. Cockpit heating pipe
8. Elevator control rod
9. Seat raising control handle
10. Roof side panel—Generator switches, etc.
11. Roof panel—Engine electrical controls
12. Roof panel—Radio controllers
13. Radio shelves
14. Aileron control rod—in inclined duct in cockpit aft bulkhead
15. Detachable and movable bulkhead—inclined duct in cockpit
16. Longitudinal seat beam
17. Kicking strip incorporating sockets for seat lateral tubes
18. Engine control rods
19. Cockpit heating and windshield de-misting pipe
20. Hot air pipes to kicking strip
21. Top hat stringers—brims welded to skin
22. Cabin ceiling panel—lowered for access to controls
23. Aileron control rod
24. Hinged access panel under leading edge
25. Forward main frame
26. Thermal de-icing pipe for tail unit
27. Re-circulating venturis—Cabin ventilation
28. Navigation lights
29. Electrically actuated gills
30. Cooling duct for oil cooler
31. Air intake in lower petal
32. Oil cooler
33. Fuel tank access panels
34. Fuel filler caps
35. Sandwich skin corrugations, chordwise at trailing edge
36. Sandwich skin corrugations, spanwise at box portion of wing
37. Aft web
38. Center web
39. Forward web
40. Drag member pick-up bracket
41. Control locking control cable
42. Center section forward attachment joint
43. Nacelle and undercarriage forward pick-up brackets
44. Undercarriage ribs
45. Nacelle and undercarriage aft pick-up brackets
46. Undercarriage pick-up bracket bracing tubes
47. Engine mounting to bulkhead joint at nacelle top longeron
48. Flap guides
49. Flap operating rods
50. Outer plane to center section joint
51. Diaphragm at 10% chord
52. Trim tab operating rod
53. Rudder post
54. Fin to frame attachment points
55. Tail plane web to frame attachment points

Herald

rather complicated system of valves allows any engine to draw from any of the four standard tanks. The system meets British and American airworthiness requirements; nowhere does a fuel line enter the cabin. Normal tankage is for 700 imperial gallons, and provision for another 300 can be made.

A tricycle undercarriage layout gives a level loading floor plus ease of loading. Each unit is equipped with twin wheels. Low pressure tires, 50 psi, give low ground stresses and enable operation from soft-surfaced fields. Main-wheel legs retract forward into the inner engine nacelles; thus the advantage of gravity and air drag aid lowering.

Despite the area-increasing Fowler flaps, for the type operation the *Herald* is designed for, its touch-down speed may be considered high at 97 mph. Reversible pitch propellers can be fitted, and indeed they may become mandatory for bush flying with this aircraft. At present no slots or other high lift devices, apart from the flaps, are fitted.

● ● Spot-Welded Structure

Although the *Herald's* layout is conventional, its structure is unusual. This has been dictated by two reasons: first is the use of heavily stiffened wing skins; the second is the extensive use of spot welding in the main airframe. The stiffened wing skins are designed to carry a large proportion of lift bending-loads. Their use obviates the need for heavily stressed spar boom members; consequently a good fatigue life for the wing is anticipated.

Spot welding for primary aircraft structures is a novel method as far as the British industry is concerned, some members of which have proclaimed it unsafe. It has of course been used for years on fairings, cowlings and other secondary parts. There is little doubt, that Handley Pages first developed this type structure for the *Victor* bomber and one may surmise there is a family resemblance between the bomber and civil transport.

Considerable time and money has been spent to develop special design and production methods. Numerous tests have been made on many hundreds of specimens, the results of which have gone to develop an adequate inspection system. So sure are the makers of their methods, that they claim to be able to produce a spot-welded primary structure with an integrity at least equal to the normal riveted type. Advantages claimed are a slightly reduced structure weight and a smooth clean finish with a minimum of skin distortion and wrinkles.

Data from tests have determined the optimum machine setting for various materials and thicknesses. Thus for any particular job, the appropriate machine settings are made by the shop foreman on each individual machine. These are then checked by an inspector, whose signature allows welding to proceed.

Table 1—Characteristics of Handley Page Herald

Maximum weight	34,000 lb
Wing loading	38.55 lb/ft ²
Power loading	9.77 lb/bhp
Span	95 ft
Length	70 ft 3 in
Wing area	882 ft ²
Takeoff run	1410 ft
Takeoff run over 50 ft obstacle	1720 ft
Takeoff speed	99.5 mph.
Rate of climb (rated power, 10,000 ft)	1125 lpm
Maximum speed at 3800 ft	263 mph
Maximum cruising speed at 10,000 ft	254 mph
Range with maximum payload (10,705 lb)	348 mi
Range with full tanks and 6930 lb payload	1417 mi
Four 870—hp Alvis Leonides Major engines	

Before actual aircraft components are welded, three test pieces are made on each machine. One piece is tested to design load in the workshop; if satisfactory, work goes ahead. Afterwards the three test pieces are taken to destruction, the data being correlated on a quality control chart for that machine.

Such charts show at an early stage whether there are dangerous trends towards low strength welds; thus corrective action may be taken before it is too late. By examining test specimens at regular intervals throughout the day, the company can maintain a constant surveillance of weld quality.

Inspection of all components before joining insures correct assembly. A finishing partial X-ray inspection of the welds themselves indicates the quality of joining in the finished product.

Rather surprisingly, spot welds are visible on a radiograph; this results because of varying transparency across the weld. Strength of the weld can be

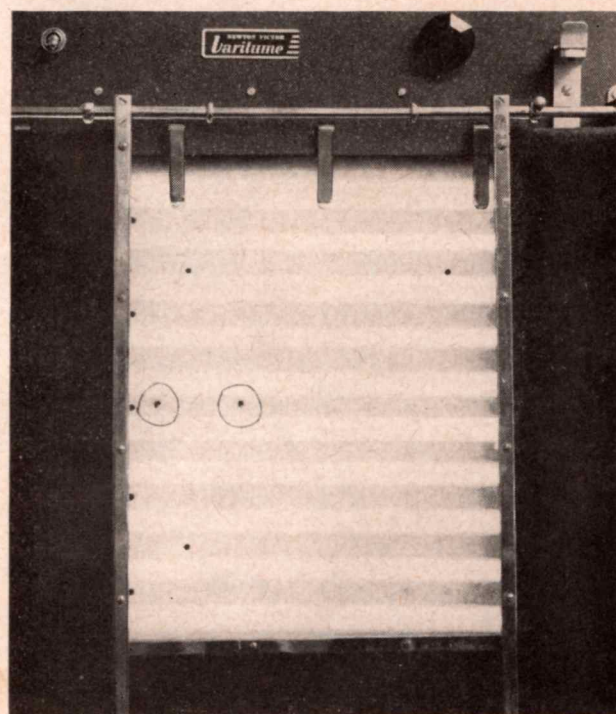


Figure 2—Faulty spot welds can be detected by x-ray techniques. Two faults are circled.

estimated from the X-ray picture and of course defects seen. Again a background of experience has shown that there is a relationship between weld diameter and strength.

An understandable caution during the development of the manufacturing process dictated that every weld be X-rayed, Figure 2. After 350,000 welds had been viewed, it was found that as long as well-fitting parts were joined, such close scrutiny was unnecessary.

A scheme has been derived whereby sample radiographs, chosen at random positions, are taken. These are carried out upon an assembly until it is known whether to reject or accept it. Previous experience has shown where the reject/accept point lies. Under the prevailing system, panels with an indicated 5 percent of their welds defective are rejected as indeed are most of those where only $2\frac{1}{2}$ percent are indicated defective.

This method has proved sound in practice. Millions of welds have been made, only ten percent of which were actually inspected, yet no failures have been reported so far. Of course a rejected panel is not necessarily scrapped. A full examination shows where the defective spots are: the panel can then be passed back to the operators who put extra spots in the troublesome locality. A final complete inspection then follows.

● ● Structural Economies

Any aspect of engineering is a compromise between conflicting requirements and naturally has its supporters and critics. So it is with this method of constructing aircraft; but no matter what is said on either side, there is one overriding consideration. For economy of manpower and speed of fabrication it cannot be beaten. One may show as proof the fact that the

Herald prototype, a 34,000-pound aircraft with a 95-foot wing span, has been built from scratch in just over 12 months—almost certainly a record for the British industry.

Examination of the airframe shows where deviations from standard practice are made. In the main skin, stringer panels are made flat and then laid over the contour-forming structure. Stringer spacing on wing and fuselage skins is close.

Fuselage rings are made in two parts, by means of a sector hoop joining a segment sheet-metal pressing. The pressing has a larger radius contour than the hoop and gives support to the floor and bottom fuselage skin. Although the squashed circle cross-sectional shape gives a few structural and stressing difficulties, it allows a good floor width for a minimum cross-sectional area. A chine member runs along each side of the fuselage at the point where one arc joins the other.

Above the floor level, skin stringer-panels are laid over the rings and attached to them by a single hollow rivet where the hat-section stringers touch the ring outer flange, Figure 3. Below floor level the pressings are notched to take the stringers and allow the skin to lay against their flanges; ordinary snap head rivets join the two. A similar arrangement prevails on the outer wing panels.

● ● Wing Design

Wings are built in three parts, plus the tips. The center section carries the four nacelles, main undercarriage units, and fuel cells. By virtue of the corrugated sandwich skins, I section spar, and two shear beams, very few ribs are used in its construction, Figure 4.

Booms and the web of the I section spar are made

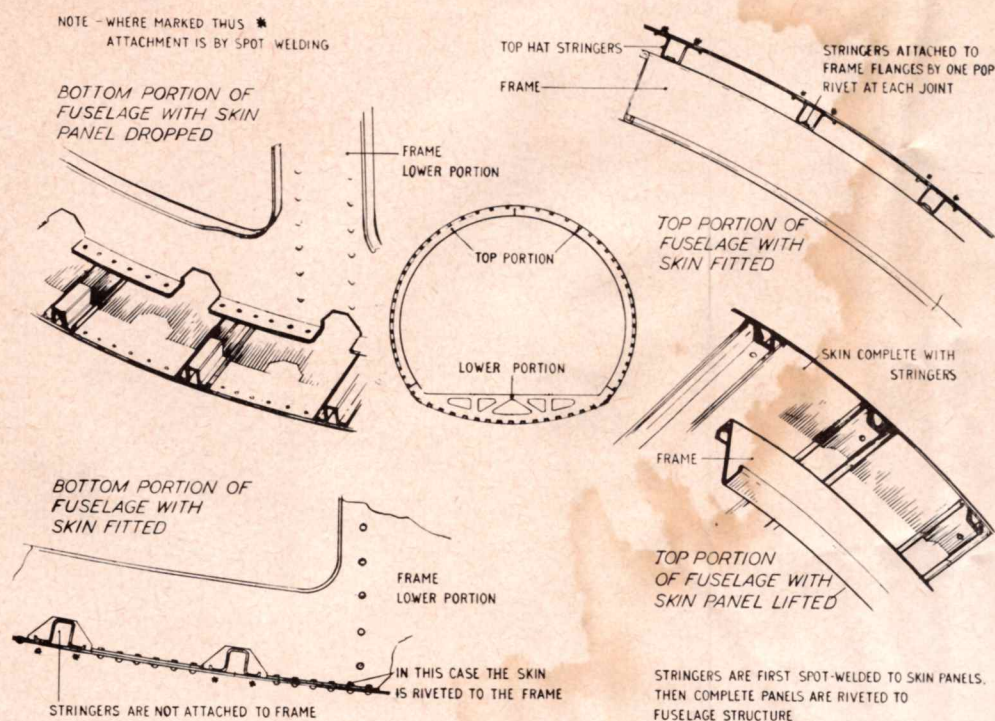


Figure 3—Details of fuselage construction show how flat panels are easily fitted to basic frames.

Herald

from corrugated sandwich skin. Corrugations run spanwise in the booms and vertically in the web; stiffeners are fixed to each side of the web over a large part of its span.

Shear and bending loads are carried by the spar, but only shear is carried by the two shear beams; in detail, these shear beams are flat sheet with vertical stiffeners; no booms are attached to them. Fuel cells are carried in the boxes formed between the spar and shear beams, the heavy sandwich skins forming the bottom and lid.

Outer wing panels have spanwise stiffened skins and light spars consisting of shear webs and small booms. Fixing of the outer wings to the center section is effected by numerous bolts passing through mating flanges on each wing panel. The flanges are on the wing exterior, being covered by a streamline fairing once the joint is made.

All tail surfaces are multi-spar structures having very few ribs. Fixed and moving parts of the empennage are covered with fluted skin, except for the leading edges. These, like the leading edges of the wing, consist of a smooth outer skin supported by a corrugated inner skin. The chordwise running gullies so formed are used for hot air circulation, if thermal de-icing equipment is fitted.

As supplied, the *Herald* has no de-icing equipment fitted, but either thermal or element de-icing can be provided to customer requirements.

By choosing four Alvis Leonides Major engines, the designers show considerable courage for as yet the engine is new and relatively untried. Should the engines, which give 870 horsepower at takeoff, prove unreliable, great difficulty will be experienced in finding alternative powerplants.

Gas-turbine power was considered during the design stage, but a realistic staff ruled it out on the ground of power losses at high air temperatures. Should a suitable turbine become available in the future, then little difficulty will be experienced in adapting the airframe.

END

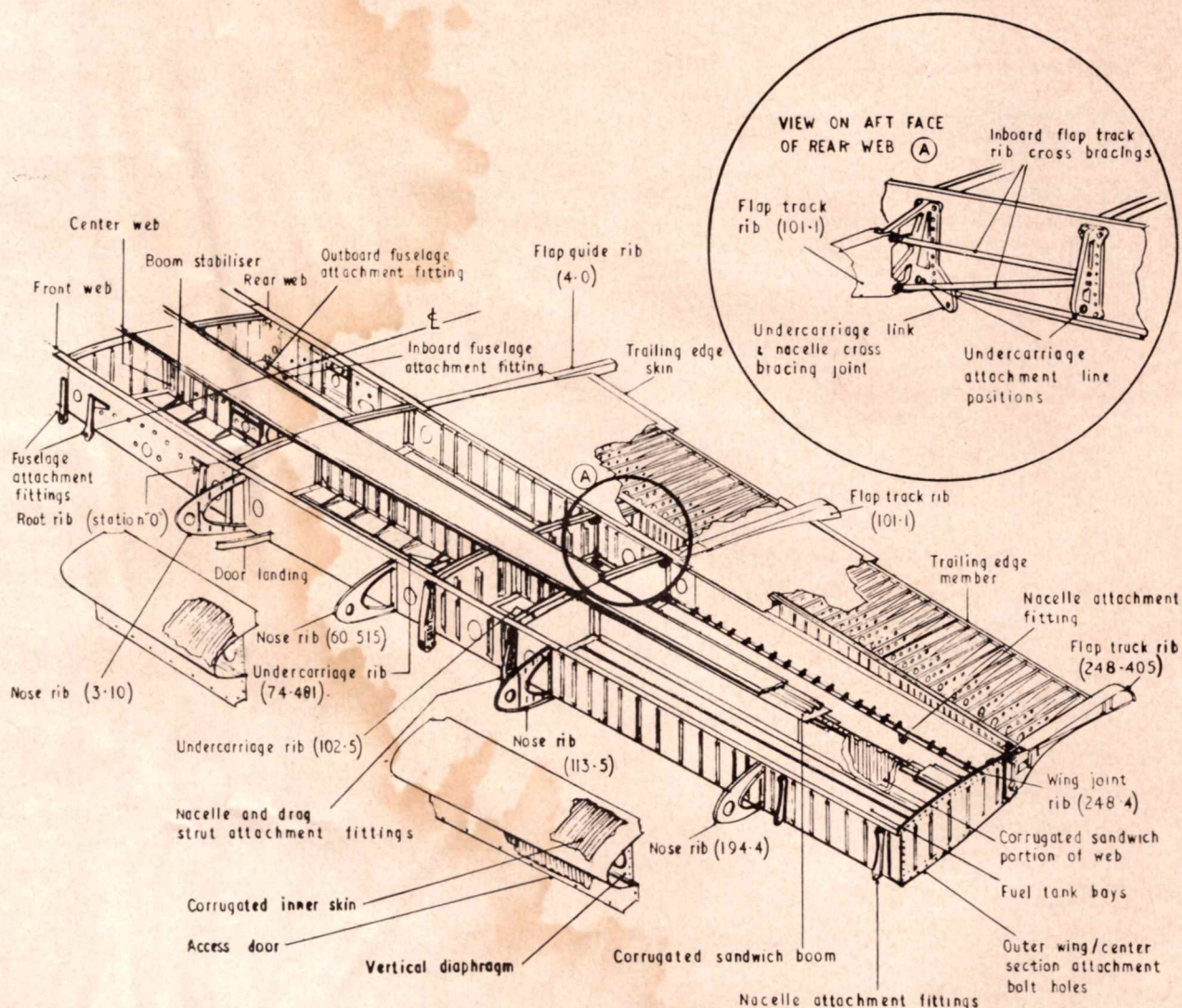


Figure 4—Structure of wing center section.

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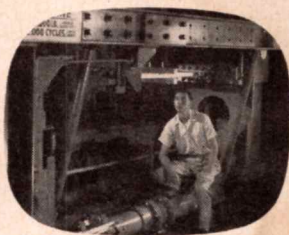
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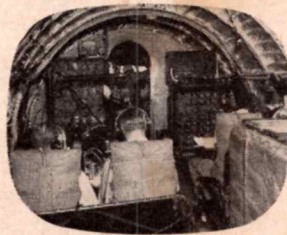
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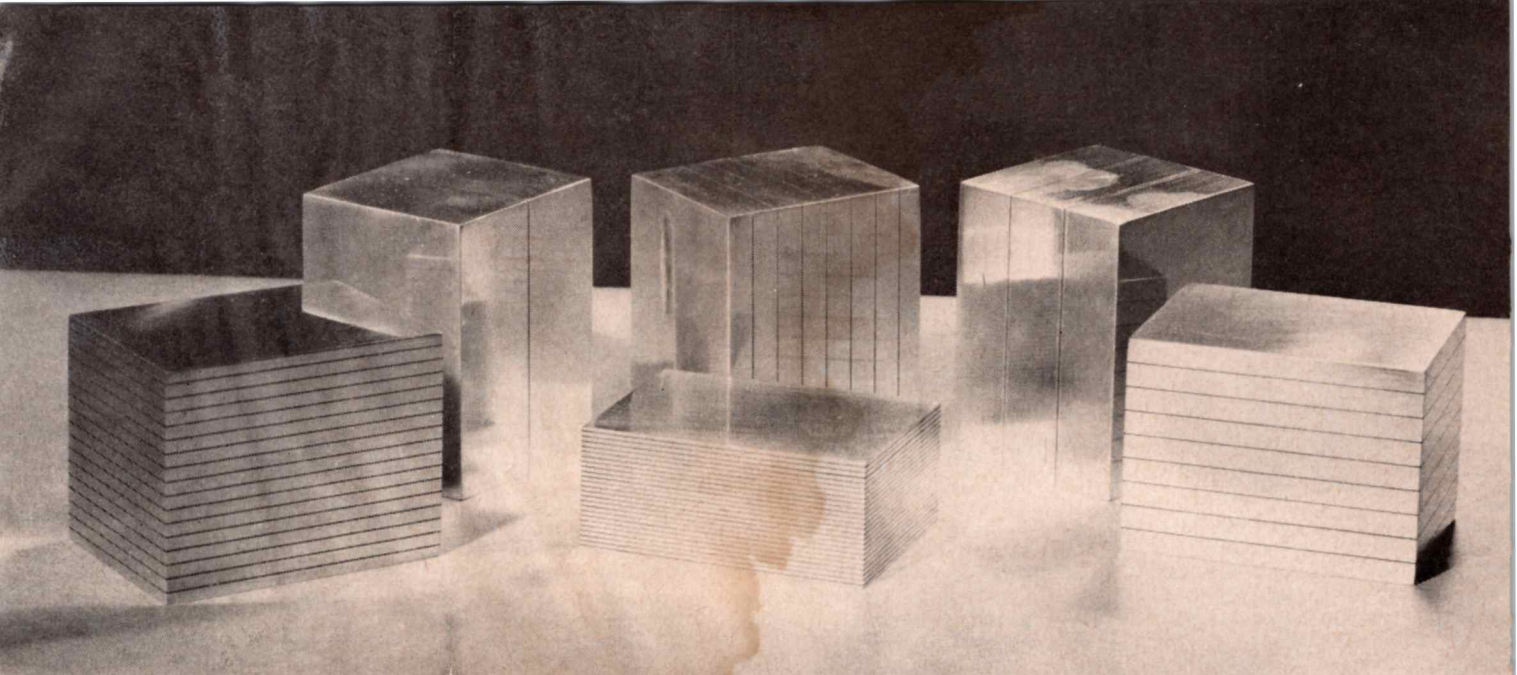


Figure 1—Samples of metal laminates.

Manufacture and Properties of METAL-TO-METAL LAMINATES

By **J. J. SAUNDERS**, Group Engineer and **H. R. MERRIMAN**, Research Chemist
Structures Department, Engineering Division
The Martin Company of Baltimore

ADHESIVE BONDING of metal laminates now can reduce manufacturing costs and simplify aircraft production. Recently a successful metal lamination process was developed by The Martin Company of Baltimore under the sponsorship of the Preparedness Branch, Industrial Resources Division of the Air Material Command. Metal lamination is a form of adhesive bonded construction which has proved practical for structural use in aircraft, missiles and helicopter rotor blades.

In this process, several large sheets of aluminum are bonded with FM-47 film adhesive to form various thicknesses of metal. Figure 1 shows some of the versatility of this technique. Mechanical tests have compared the bonded laminates with single sheets. Other tests are determining the design criteria for application of the laminates to large areas in tension and compression, with holes and cutouts, for compression panels and for panels subjected to axial fatigue loadings.

• • Advantages

The use of laminated metal in place of milled, tapered skins in aircraft offers several advantages:

1) Expensive and time consuming operations are eliminated. Standard aircraft aluminum sheets can be pre-cut to shape, stacked in step form to achieve the desired taper and then bonded.

2) This process also eliminates the large quantity of scrap produced by milling operations, which can amount to 90 percent of the initial slab. This is important costwise and in strategic planning.

3) Many combinations of materials can be used advantageously. For example, the outer laminations of a highly stressed spar or wing skin assembly might consist of a high tensile strength, corrosion resistant stainless steel, while the inner laminates of the assembly could be a lower density, lower cost material.

Laminated metal has been used in the past in the construction of transformers, electric motors, magnets, armatures and in other mechanical devices. Following World War II, and owing to a lack of heavy milling equipment, tapered laminated wing-spar booms were bonded and placed in production in Holland. Tests showed that entire sections could be formed by bending after bonding. Additional data on the actual process used in this application can be obtained from Fokker Aircraft Reports.

• • Laminated Wing

The Martin company laminated the first successful wing skin. In 1948 the XB-61 *Matador's* wing was surfaced with layers of 0.025, 0.040 and 0.020 inch 75 S-T Alclad. The following year the wing's construction incorporated a honeycomb core contoured to airfoil shape and bonded to the laminate-tapered skins. Later, the skins consisted of three plies of 14 S-T Alclad bonded with FM-45 adhesive. The outer ply was 0.025 inches, the middle ply 0.040 inches and the inner ply 0.025 inches. A similar wing construction was applied successfully to the production B-61 in 1950, with laminated skin thicknesses of 0.025, 0.040 and 0.051 inches plus large doublers 0.032 and 0.080 inches thick.

Until 1950 Martin's experience in producing and using metal laminates was limited to certain constructions for use on non-piloted aircraft. Since they were eventually to be applied to piloted aircraft, however, there were other problems to be solved.

Processing variables had to be explored. The materials are heated in the press before pressure is applied in the bonding cycle, and the time-temperature history of this process governs the effectiveness of the bond.

It was necessary to know the interrelated effects of time with elevated temperatures on the maximum thickness and total number of plies that could be bonded successfully. Consequently, additional data were needed regarding the rate of heat transfer across a number of adhesive lines into the centermost bond line. This rate varies with the number of the laminate's adhesive lines and the thickness of the metal plies.

Using a maximum heating period before bonding pressure is applied, a number of laminates were produced with a common total thickness but varying numbers of adhesive lines, Figure 2. The flexural strengths and moduli were used to determine the influence of the number of adhesive lines and the relative degree of cure across them. The flexural strength of the laminated metal at elevated temperatures was studied in relation to the adhesive line thickness, number of adhesive lines, testing temperature and the modulus of rigidity of the adhesive (as influenced by the degree of cure for a given adhesive system).

● ● Manufacturing Process

Following a close study of the manufacturing variables, the process was prepared and tested for shop reproducibility. Ten large panels, consisting of 11 plies of 0.125 inch metal, were manufactured with standard shop facilities. The process consisted of the following steps:

- 1) The metal sheets were cleaned in chromic-sulfuric acid etching solution.
- 2) Each sheet was sprayed with a primer coat of FM-47 adhesive. The adhesive then was applied to one side of each metal sheet.
- 3) The sheets were air dried for a minimum of 2 hours and then force dried at 250 °F for one hour.
- 4) Assembled laminates were loaded into a press with a platen temperature of 350 °F and were preheated. A thermocouple was inserted between the center plies. The preheat pressure was two psi, minimum. When the thermocouple indicated 315 °F at the center adhesive line, the press was allowed to breathe for 90 seconds before the thermocouple was removed.
- 5) Laminates were cured for two hours at 350 °F at 200 psi, and when the curing cycle was completed, were removed and cooled.

To date, up to 25 sheets of 0.025 inch metal have been bonded successfully at Martin. Thicknesses up to 2½ inches, using ½ inch metal, have been achieved.

The equipment used in the process consists of standard bonding presses for heat and pressure. The temperature and pressure used will naturally vary,

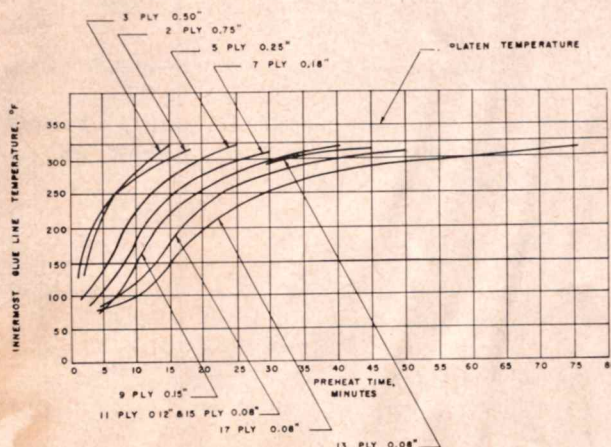


Figure 2—Time-Temperature relationships during preheat at innermost adhesive in various laminates.

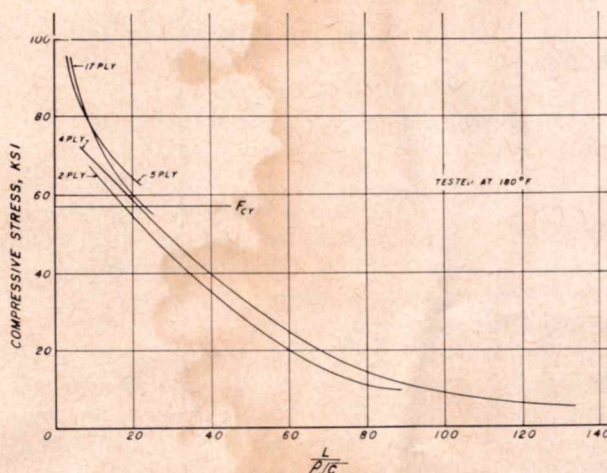


Figure 3 — Compression curves for metal laminates (tested at 180°F.).

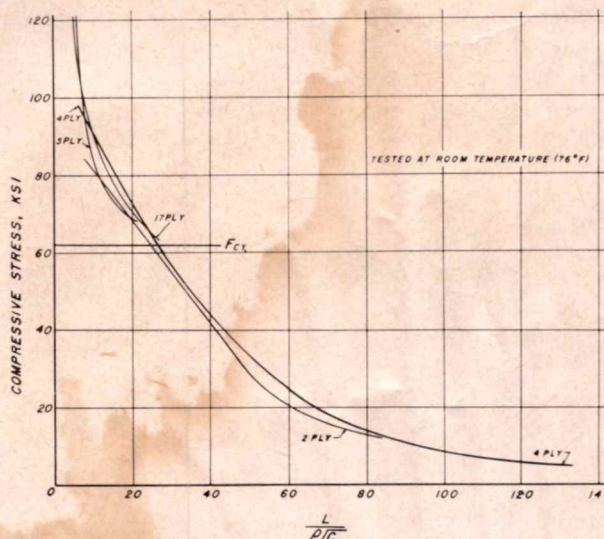


Figure 4—Compression curves for metal laminates (tested at room temperature—76°F.).

depending upon the temperature and strength requirements of the end product.

While there appear to be economic limitations on the total thickness of a laminate that can be processed successfully at this time, electrical resistance heating or some other electrical technique eventually will remove these restrictions.

● ● Physical Properties

The mechanical properties evaluated were: tension and compression loading applied parallel to the laminations, flexure developed by loads applied normally to a panel, bearing of bolts in the laminate, flexural fatigue with complete reversal of loads and flexural creep.

Bearing tests were performed at room temperature only; the results indicate no deviation from results on single layer material. Fatigue tests also were performed at room temperature; the fatigue life of laminates is comparable to that of single layers at the test temperature.

Tension, compression and flexure tests were performed at room temperature, 180°F and 260°F. At room temperature little difference was registered between the ultimate stress levels and modes of failure of the laminates as compared with single layer metal specimens. However, with increased temperature, greater difference was noted. When the departure in behavior is slight, as in some loadings, little modification of present design techniques is required. In other loadings there is such a departure that new design techniques must be used.

A laminated flexural specimen was studied to determine the strain and stress distribution throughout it. Strain gages were attached at six spanwise locations on every ply of metal in the laminate. The analysis of strain and deflection data showed clearly that, at room temperature, the behavior of the laminate was identical to that of the single layer specimen. The moment and shear distribution was calculated by the simple formulas used for beams in bending. At the higher temperatures, the analysis of deflection data indicated shear strains were increasing in the adhesive lines, resulting in a slight change in shear distribution with depth and a change in the flexural modulus of elasticity.

● ● Test Data

Figures 3 and 4 are compression curves developed from test data for a variety of metal laminates. Notice

that in the long column range there is no appreciable difference in behavior from one temperature to another. However, in the lower range, up to about $L/\rho c = 60$, the elevated temperature causes the compression specimens to fail at lower stress levels than could be sustained by specimens at room temperature.

The curves in Figure 5 result from flexural creep tests performed at 180°F and 260°F. These particular specimens, made of 17 plies of 0.025 inch 75 S-T6 aluminum, were tested with a span of 14 inches. Their loading was concentrated at the midspan, and the curves indicate the variations in creep deflections at the two test temperatures and at several loading values.

● ● Applications

A potential application for metal laminates is as sculptured tapered wing and tail covers. An artist's conception of such a wing cover is shown in Figure 6.

Other possible applications are in supplanting hogged-out fittings when considerable machining is required and as substitutes for large forgings. Preliminary gunfire tests indicate that laminated metal can be used to excellent advantage as armor plate. Laminated metal can be roll-contoured successfully, although the limits of radii for different sheet thicknesses have not been determined fully. Square bars of laminated metal have withstood turning of threads, drilling of holes and other severe machining. END

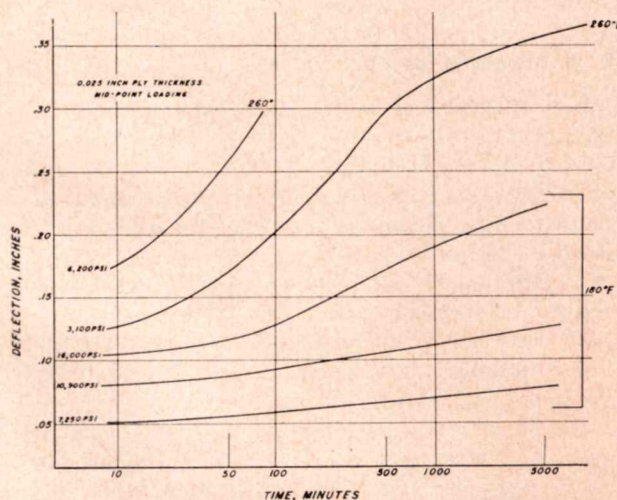


Figure 5—Flexural creep curves for 17-ply specimens.

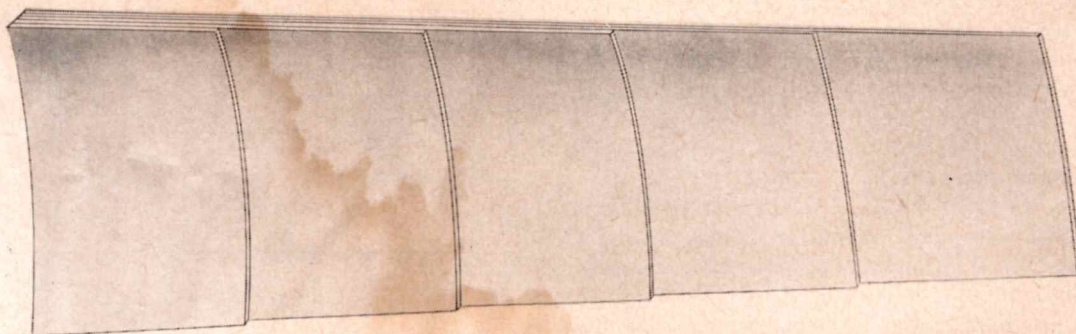


Figure 6—Artist's conception of laminated wing cover.

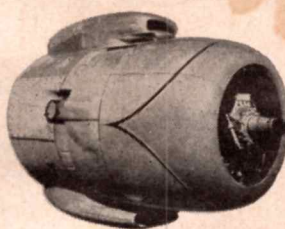
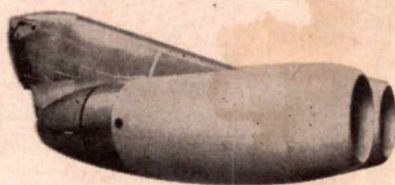
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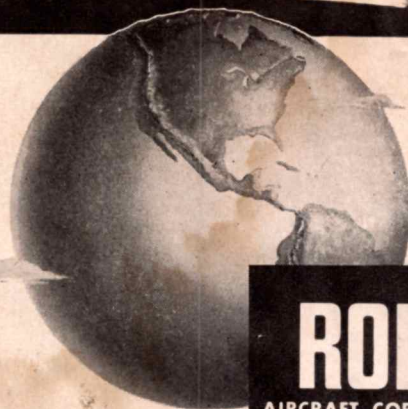
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Small Scale Testing of LIGHTNING ON AIRCRAFT

By **A. C. VAN DORSTEN**

Chief Scientist
N. V. Philips' Gloeilampenfabrieken
Eindhoven (Netherlands)
(Courtesy of North American Philips Co., Inc.)

THUNDERSTORMS are violent atmospheric phenomena on such a large scale that it hardly seems feasible to simulate them in small scale laboratory experiments.

However, it is possible to study certain aspects of these phenomena by means of scale experiments, especially in those cases where the effects are essentially unchanged by the scale. An example is the impulse testing of insulators and transformers at high tension to simulate the effects of lightning striking a power line.

The photographs in this article are illustrative of quite a different investigation undertaken recently in Eindhoven. The problem is concerned with the question as to what parts of an aircraft flying through a thunderstorm region are most likely to be struck by lightning. With the increasing speed and size of modern aircraft it has been found that incidents of this kind are becoming more and more frequent. Although accidents only rarely result from aircraft being struck by lightning, some damage, often only slight, usually results. In order to maintain full airworthiness the damage

will probably have to be repaired before the next flight; this means loss of time which can have serious effects on the economics of operations.

To help investigate which parts of an aircraft are most susceptible to a lightning stroke, a model aircraft, scale 1:100 is suspended from insulating threads between two high tension electrodes (of dimensions of some yards, see Figures 1 and 2). One electrode is connected to earth, the other to the positive high tension terminal of a million volt cascade generator. The separation of the electrodes is such that spark-over occurs

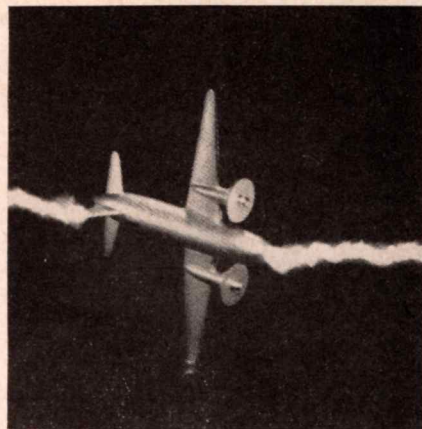


Figure 2 — Closeup of
of discharge on aircraft.

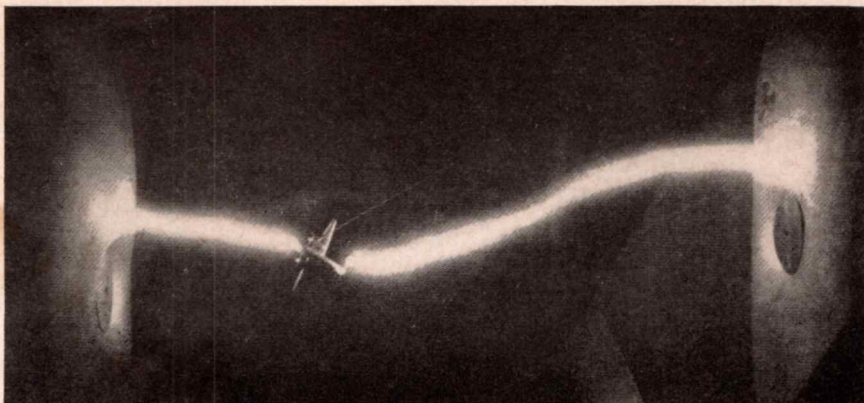


Figure 1—Model aircraft receiving electrical discharge.

spontaneously at any smaller separation. Only a faint brushing (corona discharge) occurs. This is caused by factors such as the inevitable roughness of the electrodes and dust particles on the surface; brushing is also sometimes observed on the model aircraft. The total value of such corona currents is very small, a fraction of one-ma. In the space between the electrodes around the model airplane, however, a critical condition of electric stress into a disruptive discharge by any slight change. A similar condition on the verge of a dis-

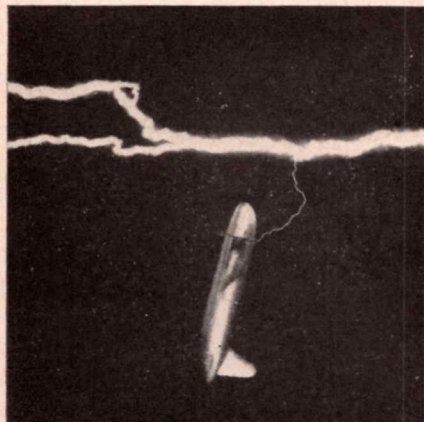


Figure 3 — Aircraft receiving secondary discharge from main spark.

charge may also prevail around an aircraft in a thunderstorm. A discharge can then be triggered by any transient factor causing a momentary increase in field strength at some point. As the experiments involved a large number of bolts of lightning—sufficient, that is, for a statistical evaluation of the results—it was obviously impractical to wait each time for a chance disturbance. Instead, a disturbance was induced by shooting a pellet from an airgun against the high tension electrode. Once the voltage had been adjusted near enough to the critical value, nearly every shot would trigger a full discharge.

Not all, but a large number of the discharges thus triggered, chose a path via the model aircraft. On one or two occasions the model was struck by a secondary discharge branching off from the main discharge, Figure 3, a phenomenon which has also

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For further information circle Reader Reply No. 42

been observed with natural lightning.

The place at which the model aircraft was struck by the discharge was photographically recorded. The aircraft model was placed in every conceivable spatial attitude with respect to the electric field. From the many hundreds of photographs it was

possible to form some idea of the parts of the model most likely to be struck by the discharge.

On the basis of experiments of this kind it may well be possible in the future to provide certain points on aircraft with lightning arresters to prevent or minimize damage. End.

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International Calendar

- Nov. 8-10—Sixteenth annual NATION-
AL AVIATION TRADES ASSOC.,
Hotel Westward Ho, Phoenix, Ariz.
- Nov. 9—Synposium on THE MECHA-
NISM OF PHASE TRANSFORMA-
TIONS IN METALS, Institute of
Metals, London.
- Nov. 9-10—Society of Automotive En-
gineers FUELS & LUBRICANTS
Meeting, Bellevue-Stratford Hotel,
Philadelphia.
- Nov. 9-11—Nineteenth annual INDUS-
TRIAL MANAGEMENT Society,
Hotel Sherman, Chicago.
- Nov. 14-15—Twenty-sixth meeting of
AVIATION DISTRIBUTORS AND
MANUFACTURERS ASSOCIATION,
El Mirador Hotel, Palm Springs,
California.
- Nov. 14-17—Second International
AUTOMATION EXPOSITION, Chi-
cago.
- Nov. 14-15—Sixth Divisional Confer-
ence, ANALYTICAL CHEMISTRY,
Sarnia, Ontario, Canada.
- Nov. 23-25—Society of Chemical In-
dustry Congress on DOCUMENTA-
TION OF APPLIED CHEMISTRY,
London.
- Nov. 28-30—I. R. E. INSTRUMENTA-
TION Conference and Exhibit,
Atlanta.
- Nov. 28-Dec. 1—Ninth AIR CONDI-
TIONING & REFRIGERATION Ex-
position, Atlantic City, N. J.
- Nov. 30—British NUCLEAR ENERGY
Conference, Inaugural Meeting,
London.
- Nov. 30—International Advisory Com-
mittee on DOCUMENTATION AND
TERMINOLOGY IN PURE AND
APPLIED SCIENCE, Brussels, Bel-
gium.
- Dec. 2-3—Eight Annual AVIATION
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ministration. Tucson, Ariz.
- Dec. 5-9—Second COMBUSTION Col-
loquium, Liege, Belgium.
- Dec. 10-16—NUCLEAR ENGINEER-
ING AND SCIENCE Congress, or-
ganized by Engineers Joint Council,
Cleveland.
- Dec. 12-16—NUCLEAR ENGINEER-
ING and Science Congress, spon-
sored by Engineers Joint Council,
Public Auditorium, Cleveland.
- Dec. 15-17—Fall Meeting, USA Na-
tional Committee, IRSU (INTER-
NATIONAL RADIO SCIENTIFIC
UNION), University of Florida,
Gainesville, Fla.
- Jan. 23-26—Seventh Plant MAINTENANCE & ENGINEERING Conference, will be held at Convention Hall, Philadelphia, Pa.

For further information circle Reader Reply No. 24

NEW EQUIPMENT

For further information concerning New Equipment listed below, make use of our Reader Reply Service. You may obtain this information by circling the appropriate number on the Reader Reply Card on page 69.

Quarter-Turn Fastener. Lightweight, low cost, positive locking is provided by fast-acting quarter-turn **Lion** fasteners which can be opened and closed repeatedly. Designed to hold plates of metal, plastic or plywood pressure tight, **Lion** fasteners withstand shock, vibration and extreme stress, says the manufacturer, Southco Division, South Chester Corporation. They are suited for fastening maintenance and inspection panels on aircraft, trucks, busses, electronic equipment, air conditioning units and other applications. Patented full-floating leaf spring assures quick access with complete safety. They cannot be partially or incorrectly locked, nor can they be over-torqued. Only slight finger pressure is required, and no instructions are needed. (E-1)

Tube Shield. A new IERC heat dissipating TR series tube shield, designed for direct replacement of JAN-type shields, enables the retrofitting of existing equipment without extensive modification, according to International Electronic Research Corporation. When this shield is used, up to 50 percent reduction of the bulb temperature reached when tube is enclosed in a standard JAN shield is attained, resulting in greatly increased reliability. (E-2)

Automation Machine. Douglas Roesch, Inc., electronic manufacturers, recently announced the completion of a revolutionary new machine which can produce special electronic cable heretofore deemed costly and impracticable. The new **Planetary Cabler** is believed by Roesch to be the answer to many current problems in the field of automation in general; and, in particular, it has direct application to the guided missile, computer and atomic energy fields. The new machine has been designed and built to provide complex reliable cables or complete prototype or production components. (E-3)

New Level Controller. A new level controller that combines the practical advantages of both electronic and air pressure control instruments has been developed by Fielden Instrument Division, Robertshaw-Fulton Controls Company. The new device, called **Pneutronic** level control, utilizes the accuracy of electronic capacitance sensing elements to detect minute changes in levels in tanks, drums, process baths, pipelines and other conveyors. Electronic signals are then converted by the **Pneutronic** control into proportional pneumatic output. This modulating air output, the company says, is sufficiently powerful to operate control valves and other

pneumatic control equipment. Eliminated are servo motors and other re-balance mechanisms which, according to company engineers, form the weakest link in any control systems, which use them. (E-4)

Interceptor-Fire Control Simulator. New Model 10 **Interceptor-Fire Control Simulator** recently developed by West Coast Electronics Co. is designed to simulate the operation of an interceptor-fire control system of the E-4, E-9 or E-10 type during the attack phase of interception (the period commencing just after radar lock-on and ending at firing of the armament). The new simulator provides means for simulating targets in straight line or accelerated flight. Pursuit, lead-pursuit and lead collision attacks are simulated at the discretion of the operator. The new Model 10 simulator has special application as research equipment for use in investigation of pilot problems pertinent to the operation of interceptor fire control systems, or for use in laboratory design studies of cockpit controls and displays. (E-5)

Lead Checker. A lead checker that uses jaws carrying V edges and capable of being attached at any desired spacing, setting being eased by a fine adjustment screw, is produced by Standard Gage Company, Inc. A spring-loaded lever snugs the workpiece against the Vees, and the lead variation is read directly on the indicator due to the parallel sliding action of the basic **Versa-Dial** unit. Jaws regularly stocked are suitable for pitches from 10 to 40 threads per inch and diameters up to one inch for American National and Unified Threads. Jaws for finer or coarser threads can be furnished as specials. The lead checker is ordinarily supplied with an indicator graduated in .0001 inch and the manufacturer claims comparable accuracy for the instrument as a whole, as well as particular ease and speed in operation. (E-6)

Diameter Gage. An instrument for the measurement of pitch diameter of threads is manufactured by Standard Gage Company, Inc. Claimed by the manufacturer to be in their own right the equivalent of more expensive instruments, they utilize the **Versa-Dial** gage as the fundamental unit, as does the previously announced thread-checker for over-all assembling characteristics. Capable of being fitted with a variety of contacting elements, the **Versa-Dial** can check groove diameters, shallow counterbores and a number of other kinds of dimensions

as well. Measurement of pitch diameter is basically by the three-wire method, but with holder devices of such design that the operator of the gage need not be aware of the wires themselves. Upper wire is approximately positioned by two plungers, which automatically recede under the effect of the gaging action. Lower wires are separated slightly by collars but limited as to maximum spacing. Wires are of tungsten carbide for most pitches.

Measuring pressure is adjustable but constant for a particular setting. Therefore the pressure is the same on the workpiece as on the master and is independent of judgment, contrasting in this respect with micrometer measurements. (E-7)

Hi-Shear Conversion Unit. General Riveters, Inc. announce the development of a **Huck** and **Hi-Shear** conversion unit for standard **Drivmatic** automatic drill riveting machines. The unit is a package which replaces the lower ram. Lower ram tooling for handling high strength fastenments is quickly interchangeable and consists of anvil and snap in collar magazines. Lower anvils and components are easily changed for various collar sizes. Slug ejection is provided for **Hi-Shear** rivets. Standard **Drivmatic** upper tooling is used to feed and buck the rivet. Slip-out tooling for standard rivets is available for use on the conversion unit. This unit has feature of providing a clear opening between anvils of 8 inches. This opening is 2½ inches more than that provided in standard **Drivmatic** and facilitates the fabrication of deeper sections. (E-8)

G-Accelerator. Genisco, Incorporated, recently completed a large rotary centrifuge for Edwards Air Force Base, Edwards, California. The new machine is capable of testing two objects up to a 30-inch cube in size and 300 pounds in weight simultaneously. Current upper range of the machine is 60 g's with a capacity of 18,000 g-pounds at each platform. A special feature of the Model E-185 is its automatic dynamic balancing. The boom assembly automatically seeks the dynamically-balanced condition by vertically shifting the composite centers of gravity of the opposing centrifugal forces until they have resolved into the same plane of rotation. This feature eliminates computations required to figure centers of gravity of test objects, speeding up test runs and minimizing operator responsibility. The machine is capable of adjusting for a wide range of weight distribution. If full platform

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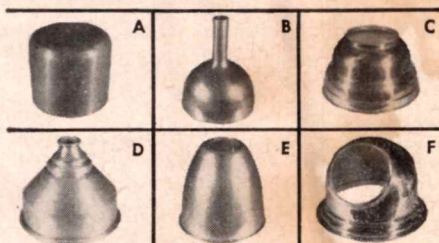
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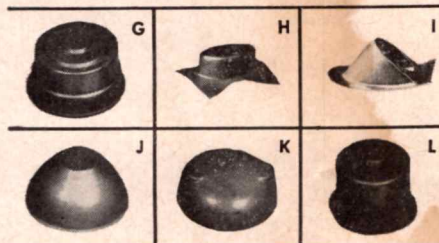
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Reader Reply No. 44

travel is inadequate to achieve complete dynamic compensation, the drive motor is automatically shut down by limit switches. (E-9)

Portable Band Saw. A new high-speed steel blade for a portable electric band saw makes it possible to cut most tough metal material such as stainless steel, carbon tool steel, nickel and high speed tool steel. Introduced by Porter-Cable of Syracuse, N. Y. and specifically designed for use with the Model 524 **Porta-Band Saw**, this special blade, along with the conventional blades, is said to permit the saw to cut practically 100 percent of all metal materials being sawed today. (E-10)

Match-Plate Metal for Castings. Salloy is an aluminum alloy developed by the Metallurgical Department of The George Sall Metals Co., specifically for use in making aluminum match-plates. Salloy produces an extremely bright surface, according to the manufacturer. Many foundrymen and casters have reported that on jobs where a highly polished surface is required the use of Salloy facilitates the operation. It is close grained and takes a good polish. While the cost of Salloy is higher than standard aluminum alloys, the results obtained and reduction of rejects actually mean less overall cost in the finished product. (E-11)

Cavity Wavemeters. DeMornay-Bonardi is now in production on a line of precision cavity wavemeters designed to give unusually broad coverage of microwave bandwidths. Only eleven sizes are needed to serve the entire range from 2.6 KMC to 90 KMC. Hence fewer sizes are required to cover wide segments of the total range. Each instrument measures all frequencies within the range. Accuracy of these units is so high that they may be used as secondary standards, suitable for calibrating all other laboratory cavities. To sustain this accuracy, a sealed construction is used, together with ball bearings and gas pressurization, features which assure permanence of calibration and maintenance of Q values for many years without service, according to the manufacturer. (E-12)

Non-Flaking Laminated Plastic. Laminated plastic has proved to be an ideal substitute for mica as a commutator insulating material in dc motors and generators, according to the National Vulcanized Fibre Company. Identified as Phenolite grade APO-720, the product is a polyester-resin-bonded, asbestos paper laminate that gives commutator makers a replacement for mica that is less expensive, easier to fabricate, and practical for assembly into commutators with automatic machines. Design engineers, particularly, are said to have found the new laminate an improvement over mica in low voltage generators and starting motors. Mica flakes tend to jam automatic machinery, whereas the laminate does not flake and has good punching qualities. (E-13)

Potentiometer. The Gamewell Company's new $\frac{7}{8}$ inch potentiometer of-

fers same precision found in larger sizes of Gamewell potentiometers. Body is of anodized aluminum and the shaft is made of stainless steel. Kohlrausch type winding provides linearity and the unit meets MIL-E-5400 specifications as they apply. The unit can be modified for special mounting. (E-14)

Precision Potentiometer. A new $\frac{5}{8}$ inch potentiometer that offers extreme precision is manufactured by the Gamewell Company. Body is of anodized aluminum and the shaft is made of stainless steel. Kohlrausch type winding provides linearity, and the unit meets MIL-E-5400 specifications as they apply. Unit can be modified for special mounting. Multiple gangs, higher operating temperatures and other special features also available. (E-15)

Stanpat Drafting Aids. A new time-saver for draftsmen and engineers is now available, which eliminates bore-some, repetitive copying and reduces drawing errors. Stanpat can reproduce any standard or special drawing detail, in quantity, on extra-fine, matte-surfaced acetate sheets, with adhesive on either front or back, as desired, claims the manufacturer, Stanpat. To apply, it is only necessary to peel off the protective paper coating, position the element on the tracing and press it in place. Title blocks, specification and revision boxes, instructions, symbols, standard and special components and cross-sections can be reproduced to order, with either one or several details per sheet. Stanpat allows crisp and clear tracing reproduction and will not dry out, come off or wrinkle. Blank sheets are also available to permit typing of non-standard information on drawings, eliminating tedious and costly hand-lettering. The new adhesive used on Stanpats is heat-resistant and will not be affected by any reproduction process. (E-16)

Blueprint Processing Machine. A new machine that uses electronics to turn a blueprint into a complex finished product has been developed by Bendix Aviation Corporation. Called the **Cam Machine**, the new device will accomplish in from two to four hours a technical operation which previously required approximately 400 man-hours, or from 5 to 10 weeks. According to Bendix Aviation Research Laboratories the Cam Machine has been used for almost a year to produce automatically an intricate cam which is the heart of a jet aircraft engine fuel-metering and fuel-control system. (E-17)

Forging Development. An intensified press forging development program has been launched by Harvey Aluminum. Aimed at the industrial designer and design engineer, the project provides manufacturers with technical assistance in formulating new commercial uses for aluminum forgings. This specialized engineering design service is being amplified to foster improvements in commercial and industrial products through the use of aluminum forgings, manufacturer says. Capabilities of new press forge facilities, metallurgical and produc-

tion advances and the latest engineering design information will be made available to all industrial designers and engineers. Initial development and improvement activities already under study in the new program include the use of aluminum press forgings for numerous applications.

(E-18)

Mechanized Production Resistors. New Series A encapsulated resistors for use in printed wiring circuits has been announced by Hycor Co., Inc. They are designed to conform to specifications proposed by RETMA for components to be used in automatic assembly equipment. The resistors are encapsulated in a tough epoxy compound for protection against extreme humidity, mechanical and thermal shock. The plastic is filled with heat-conducting mineral which dissipates the heat and equalizes hot spots in winding. Sealed-in terminal connections are welded. They satisfy military requirements of MIL-R-93A and JAN-R-93. Temperature coefficient: ± 0.0022 percent per degree Centigrade; operating temperature: -65 degrees Centigrade to $+125$ degrees Centigrade; Wattage range from .25 watt to 1 watt with tolerances to 0.1 percent.

(E-19)

Data Reduction Filter. A data reduction filter set for analyzing vibration frequencies in aircraft and missiles is announced by Hyco Company, Inc. In use, a tape recorder containing the complex wave form is fed into the unit which separates the component frequencies into 24 components. The unit consists of 24 cathode follower amplifiers which feed 23 band-pass filters ranging progressively from 30 cycles to 2000 cycles and one 20 cycle low-pass filter. The output of each filter appears on jacks on the front panel. A channel level control is provided for each filter. A set of jacks is also included on the front panel for oscilloscopic viewing of the complex wave form at the input. The individual frequencies may be analyzed separately to determine the exact nature of the mechanical vibration.

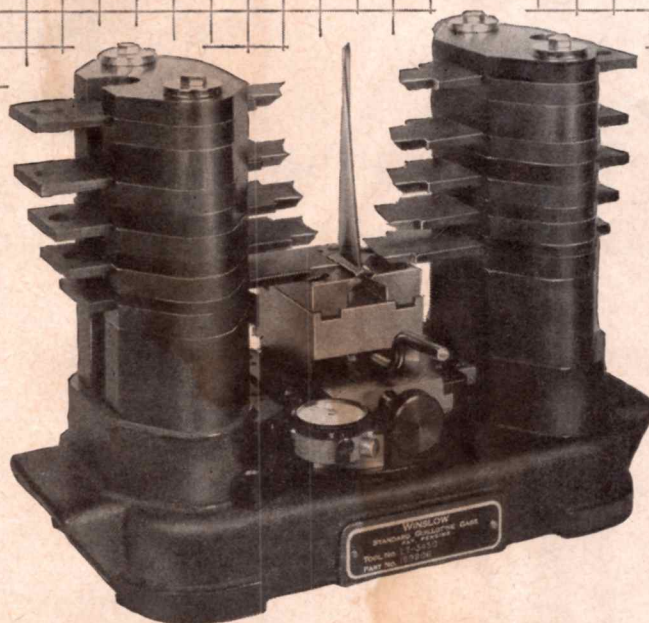
(E-20)

Circuit Connectors. DeJur - Amsco Corporation has developed new contacts now supplied with Continental Connectors printed circuit receptacles. They are available in single and double row construction of 6, 10, 15, 18 or 22 contacts. The bellows type design provides longer contact life and smoother engagement, manufacturer says. It is the only connector that accepts .054 inch to .071 inch variation of standard 1/16 inch copper clad printed circuit laminated card (receptacle to accommodate $\frac{1}{8}$ inch board also available on special order). Wiring styles include solderless wire wrap, solder lugs or taper pins for AMP 53. A choice of molding compounds is available: Mineral filled Melamine, Plaskon reinforced (glass) Alkyd 44OA and Orlon filled Diallyl Phthalate.

(E-21)

Transducer Pickup. New magnetic pickup Model 3030 is a small, rugged, impulse-generating transducer which converts mechanical motion into sufficient electrical energy to operate electronic devices, manufactured by

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inspection of jet engine blades!**



THE WINSLOW STANDARD GUILLOTINE GAGE

- assembled from stock components
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- quick delivery
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- maintains original accuracy
- lower original cost
- less down-time
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Already in use by the leaders of the jet engine industry, this new kind of guillotine gage solves the problem of maintaining accuracy. Templates are supported over a much larger area of their surface, making wear negligible. And alignment is guaranteed by heavy stacked towers that are bolted together for ruggedness and complete rigidity. Winslow's new design and assembly from precision-built interchangeable parts give six big advantages. You get quick delivery and lower original cost. You save on maintenance—in case of damage substitution of some parts can be made without even removing the gage from your inspection line.

Gage down-time is cut, requiring fewer gages and avoiding costly production holdups. And finally, you reduce your gage investment with a truly multi-purpose instrument—check all 10 features of a jet engine blade with a single gage; check forging and finished part with only one gage. No more gage obsolescence—Winslow's Re-Work Service quickly up-dates the gage when your part changes. Easy to use and easy to read, the Winslow speeds production, gives "more accuracy for less money."

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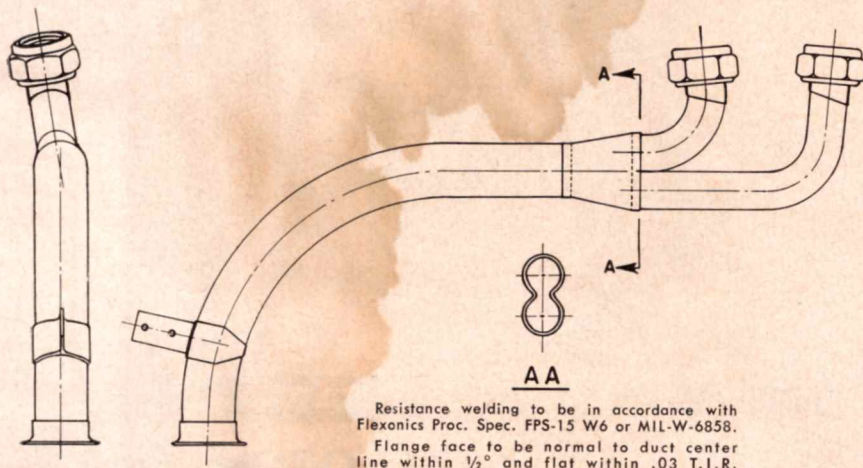
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Design Briefs

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FLEXON BELLOWS are made in an almost unlimited range of sizes and types to meet the most advanced requirements.

Intricate forming problems combined with the high dimensional accuracy requirements in production created a tough development problem in the anti-icing duct assembly sketched above. The transition-tube shown in cross-section A-A was inert arc butt formed from a single piece of welded SS 321 tubing (not two half shells welded together). The assembly is proof tested at 365 psig for five minutes. No evidence of leakage, cracking or deformation is permitted. Duct operates at 850° F.

Here's another example of the kind of weight-saving and sound engineering design resulting from years of practical experience and the most advanced manufacturing techniques. You can put this skill to work for you by sending an outline of your ducting requirements. Flexonics engineers welcome the opportunity to work with you towards the resolution of your ducting problems.

RFA-27

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For further information circle Reader Reply No. 18

Electro Products Laboratories. The new Model 3030 is sensitive modification of the standard Model 3010-A magnetic pickup. It is intended for use as a supplementary pickup to extend the magnetic pickup usefulness into the slow speed or very low excitation range. Under low excitation, the voltage output is over two times that of the more rugged Model 3010-A. (E-22)

Focusing-Magnet Power Supply. Designed for use with high-power klystrons and traveling-wave-tube focusing magnets, a continuously-variable 150-volt 4-ampere power supply with less than 0.1 percent current ripple is now available from Levinthal Electronic Products, Inc. This focusing-magnet power supply is designed to operate from 115-volt 60-cps single-phase power. Units include an under-current relay to interlock with tube beam supply and indicator light, main power switches, pilot light and appropriate fusing. Power supply is designed to fit standard 19-inch relay-rack mounting. (E-23)

Multi-Position Switch. Miniature M-12 twelve-position switch is designed by R-F Electronics, Inc., for use in applications requiring up to three amperes at 115 volts ac. Up to six decks can be ganged for operation with a single knob, allowing multi-circuit control in very limited space. The M-12 is only 3/4 inch square, and weighs 1/2 ounce. Switching action can be shorting (make-before-break) or non-shorting (break-before-make), with continuous rotation or movement limited from 2 to 11 positions. Contact terminals are of silver-magnesium-nickel alloy, rotor contacts are spring-tempered silver alloy, and the detent mechanism is made of stainless steel. (E-24)

Two-Stage Compressor. Wherever high-pressure, high-capacity compression of either air or other gases is required, the new **Standardaire** intercooled compressor will do the job economically and advantageously, Read Standard Corp. claims. It is available in capacities of from 100 to approximately 4000 cfm, ranging from 15 to 600 hp. The largest size, capable of absorbing 600 hp, weighs only 7700 pounds. Compressor includes a pair of positive-displacement, axial-flow blowers, arranged to work in two stages to boost discharge pressure up to anywhere in a normal range of from 15 to 50 psig. With appropriate inlet pressures, discharge pressures up to 125 psig are possible. For gas service, the compressor is equipped with mechanical seals; for air, with labyrinth seals. (E-25)

Tapering Machine. A new 80 ton mammoth abrasive belt machine for tapering aircraft skins has been installed in the plant of the Coated Abrasives Division of The Carborundum Company at Wheatfield, New York. The machine, the largest capacity surface grinder in the world, will soon be in operation tapering wing skins for customers in the airframe industries and the U. S. Air Force. (E-26)

Surface Comparator. A new approach to the problem of judging surface roughness of mass-produced parts is

announced by the Bausch & Lomb Optical Co. The new principle is embodied in an inexpensive surface comparator which permits metal surfaces to be compared with a selected standard for roughness under 10-power magnification. (E-27)

Silicone Lubricants. Commercial availability of silicone lubricants for jet aviation and industry is announced by the General Electric Company's Silicone Products Department. Designated Versilube F-50 and Versilube G-300 lubricants, the new lube fluid and grease are believed to be first such lubricants made available in commercial quantities. The fluid lubricant is currently being used in tests on jet aircraft components. Versilube F-50 is being evaluated both as a jet engine lubricant and for new hydraulic systems. (E-28)

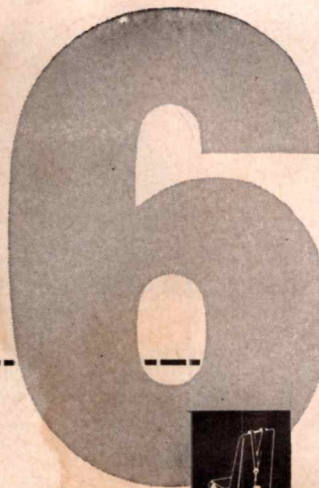
Folding Aluminum Sawhorses. Folding aluminum sawhorses have been developed jointly by engineers of the Rome Air Development Center, Griffiss Air Force Base, Rome, N. Y., and the General Electric Heavy Military Electronic Equipment Department. The sawhorses provide an inexpensive method of erecting huge, ball-shaped, air-inflated, rubberized fabric radomes which house powerful radar antennas at domestic and overseas defense outposts.

The new erection system is being used for a large number of search radar units which General Electric is supplying to the Air Force. (E-29)

Centrifugal Switches. Latest development in the line of Syncro-Snap centrifugal switches is a compact speed regulation unit, separately housed, and furnished in three types: for continuous, automatic speed regulation over a narrow speed band; as a governor-control of dual, predetermined minimum/maximum speeds over a greater speed band; to govern a single high speed or a single low speed. Packaged controls can utilize up to three independent governors for control of multiple or inter-related circuits. This new unitized speed regulator can be located almost anywhere, vertically or horizontally, to detect or control speed on practically any device or equipment utilizing rotary motion. It detects rotational speed alone, independently of voltage or load, according to the manufacturer, Torq Engineering Products, Inc. (E-30)

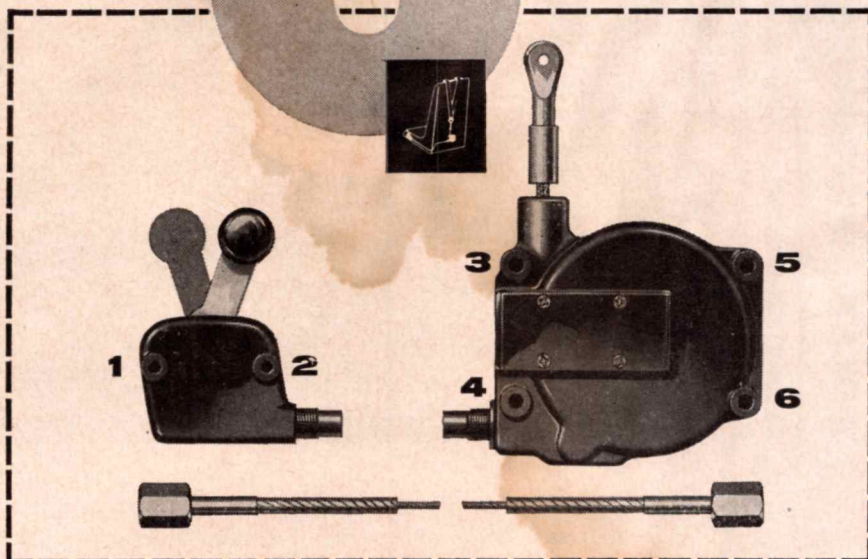
Support Brackets. Lightweight aluminum and rubber sandwich support bracket and shock mountings have been developed jointly by engineers of Stillman Rubber Co. and Lockheed Aircraft Corp. First application of the Flexmount, is to support after-body engine sections of the Lockheed Model 1049 A Super Constellation airplane. Operating under conditions of high frequency vibrations caused by the engine reduction gear train, the Stillman Flexmount is designed to withstand applied loads in shear and additional resultant loads caused by engine vibrations. These loads are taken out by 11 1/4 inch bolts, with the vibration completely absorbed by Neo-

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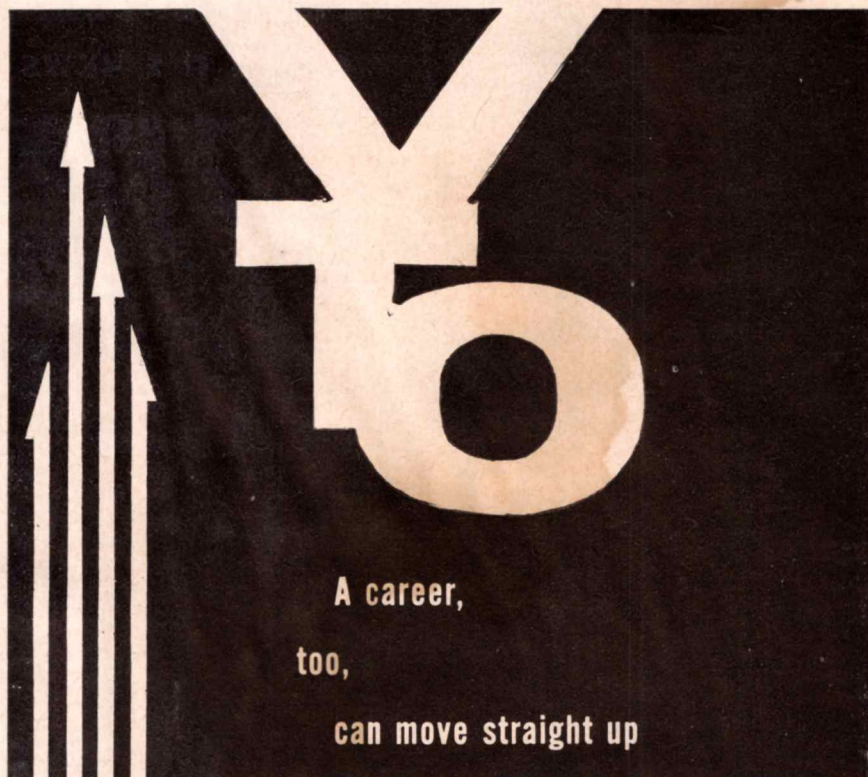
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Specialists in VTO: Take a look at Fairchild's progress in this exciting field of modern aviation!

Here is real opportunity to make your mark in this important work, offered by the fast-growing, progressive organization that gave the world the famous C-119 *Flying Boxcar* and C-123 *Provider*. For now at Fairchild extensive research and development programs are in progress to create new VTO craft, as well as transports, fighters and missiles.

If you have experience in this field, and can make genuine contributions to its advancement, then you have an important place at Fairchild, and the chance to move straight up in your profession.

Consider, too, the added advantages of living and working close to Baltimore and Washington, in the attractive Cumberland Valley, where housing, schools and recreational facilities are among the nation's finest. And, Fairchild's salary plan, paid pensions, health, hospitalization and life insurance benefits give you extra security in which to build your future.

Send a detailed resume of your experience to Walter Tydon, Chief Engineer. All correspondence will be kept in strictest confidence, of course.

*"where the future is
measured in light-years"*



prene rubber core 11/16 inches high x 1 1/4 inches wide x 1 1/4 inches deep bonded to the aluminum. (E-31)

Delay Channel. Sturup, Inc. has developed an ultrasonic delay system available as a complete unit. This new concept in the engineering and construction of delay systems is said to provide a complete unit including a compact solid ultrasonic delay line with pre-delay and post delay circuits, and a self contained, regulated power supply, particularly suiting it for radar, computer and autocorrelation systems as well as general laboratory use.

Model "500" has a delay of 500 micro-seconds ± 5 percent. Characteristics include a video response of -3 db between 10c/sec. and 4.5 mc/sec. and a signal to noise ratio of 40 db. Several units may be cascaded for longer delays. (E-32)

Flexible Gear Boxes. A series of flexible, precision-made highly-efficient gear boxes with a wide range of gear ratios, from 4:1 to 12,000:1, providing torque from 150 in.-oz. to 200 in.-oz., has been developed by Southwestern Industries. Applications include servo mechanisms, computers, small actuators and electronic components. Available in two series, 145 and 167, the small, compact gear boxes are designed so they can be mounted directly to small electric motors. If desired, they can also be supplied with an input shaft. Series 145 provides up to 150 in.-oz. of torque; series 167, 200 in.-oz. Weight ranges from 2 1/2 to 5 oz. (E-33)

Titanium Quality Certification. A major advance in titanium quality, which will help fabricators save time and reduce production costs, has been achieved with a "quality certification" introduced by Mallory-Sharon Titanium Corporation. By using statistical quality control techniques to improve uniformity of unalloyed titanium sheets, the company now certifies mechanical properties within narrow ranges. With the new certification, each heat of material is accompanied by a test report certifying an average strength level and also narrow limits of variability, such as plus-or-minus 5000 psi. These certified properties are based on a statistical confidence level of 97.5 percent. With this close uniformity thus assured, fabricators can eliminate segregation of sheets into strength level groups, as well as different tooling setups, according to the manufacturer. (E-34)

Gamma Ray Projector. A portable gamma ray projector that has advantages over conventional x-ray equipment used in radiography work has been placed on the market by The M. W. Kellogg Company. The projector is being made in three sizes, 75 pounds, 250 pounds and 2900 pounds. Styling was by Becker & Becker Associates. It will be marketed through Kellogg's recently-formed Nuclear Products Division. The gamma ray projector is safe to operate, costs only a fraction as much as comparable x-ray equipment that is used for radiography work, is extremely portable, needs no electricity, no control board, no maintenance beyond replenishment of the radio-isotope

For further information circle Reader Reply No. 17

and can take a picture of 360 degrees, according to the manufacturer. (E-35)

Hydraulic Press. A versatile hydraulic press specially designed for laboratory use, testing, laminating and rubber and plastic moulding has been put on the market by the Hydraulic Division of Kingsbacher-Murphy Co. Featuring a new design two stage hydraulic pump which automatically switches from low to high pressure, the KM-2 develops up to 40,000 pounds on the platens. The upstroke on the hydraulic control lever is used for low pressure work to raise the ram rapidly, while the downstroke is employed for high-pressure work. Individual thermostats permit accurate temperature control up to 600 degrees Fahrenheit in each of the platens by means of cast-in electric heaters which operate on either 110V or 220V ac or dc. Water cooling is made possible by cast-in steel coils which may also be utilized for oil, steam or air heating. (E-36)

Vinyl Sleeving. Vinyl insulation sleeving that serves both general purpose and specification requirements is announced by Resin Industries, Inc. Designated **Resinite EP-69A**, the new sleeving is said to exceed requirements of specification MIL-I-631B (Type F, Form U, Grades A and B, Class I and II, Category 1 and 2). It provides a working temperature range from -48 degrees Centigrade to +90 degrees Centigrade and a dielectric strength of 750 volts/mil. In addition, it performs beyond specifications for corrosion, fungus, oil and flame resistance. **Resinite EP-69A** is suitable for general purpose use because of its excellent dielectric characteristics, wide effective temperature range and oil resistance according to the manufacturer. It is available in sizes from #20 AWG to 2½ inches ID. (E-37)

Printed Circuits Varnish. A new varnish designed especially as a protective insulating coating for modular assemblies, printed circuits and printed circuit components has been developed by the Schenectady Varnish Company. Far more flexible than conventional coatings, the Schenectady #642 printed circuits varnish can be baked or air-dried to a tough, resilient coating that completely seals the laminate and component leads against arc-producing moisture, manufacturer claims. A 2½ mil coating of this water-white varnish withstands 1250 volts, even after 72 hours exposure at 100 percent relative humidity. Varnish will not support tracking, nor will it char. #642 varnish is free from aging characteristics or discoloring and may be readily thinned with **Xylol** or its equivalent. (E-38)

Circuit Analyzer. New Model 80 automatic electrical circuit analyzer which can automatically test as many as 80 circuits in one operation, is manufactured by Electronics Division of DIT-MCO, INC. The Model 80 is highly portable. It is the equal of Model 200 in every detail except capacity and incorporates the same features which are helping to break the production bottleneck caused by laborious and inaccurate hand or machine testing of complex electrical circuitry. Pri-

mary features of the new Model 80 Analyzer are high speed, automatic testing. It can test 80 circuits in eight seconds. The tester itself never has to be modified. Adapting it to test any cabling system or panel assembly requires only a simple, straightforward adapter cable, manufacturer says. The Model 80 circuit analyzer can test for all types of errors, functionally test relays, solenoids and other devices and automatically test every type of multiple, interconnected cable system for continuity, short or insulation resistance. (E-39)

Erector Set Parts Assembly. An erector set is cutting costs and speeding the assembly of aircraft control instruments according to Minneapolis-Honeywell Regulator Company. Conceived and built by tool test technicians in the firm's Aeronautical Division, the kit has been used in assembling tools, mounting panels and other fixtures to meet short-run production requirements for as little as one-tenth the cost of permanent engineering design and tooling. Most parts in the kit can be used over and over again, eliminating the cost of scrapping expensive permanent fixtures. The kit contains various-sized sheets of perforated fibreboard, perforated metal sheets and strips and an assortment of angle brackets, binding posts, stand-off legs, clamps, wing and hex nuts, bolts and other fixtures for breadboard assemblies. Perforated sheets of plastic can be added for high-voltage assemblies. From this collection of stock parts, production engineers and technicians can design and build their own wiring and temporary inspection fixtures, electrical testing panels, wiring mock-up boards and a wide variety of other assembly and machining tools. (E-40)

Small Storage Battery. Designed to power a secret instrument package for an electronics defense firm, a tiny 1/10th ampere-hour Yardney Electric Corporation Silvercel is said to be the world's smallest rechargeable battery. Suitable for a wide variety of applications requiring high capacity and rechargeability within a limited space, the high capacity, extreme small size and light-weight characteristics of the new **Silvercel** may make it extremely useful for various portable communications, recording, telemetering and photographic equipment, according to the manufacturer. The new storage cell, built on a revolutionary silver-zinc principle, pioneered by Yardney, measures only three-sixteenths by five-eighths by one-and-one-eighth inches high. Cookie thin, it weighs one-sixth of an ounce. (E-41)

Quick-Action Ball-Lok Pins. Production assembly and other types of operations are being speeded up by the adaption of new **BALL-LOK** pins which embody not only a faster lock and release principle, but an added positive safety lock feature as well, according to the manufacturer, D. W. Price Corporation. **BALL-LOK** pins are made to military specifications and are single action type, either push or pull, which permits simplicity of operation. **BALL-LOK** pin cannot be accidentally released. The release button must be depressed to disengage the lock at the time the pin is pulled. (E-42)

NAMES IN THE NEWS

Henry Blackstone, president of Servo Corporation of America, announced the promotion of: **A. Eric Theis** to vice president in charge of engineering; **Charles F. Healey** to vice president in charge of administration; and **H. Gordon Hawthorne** to treasurer.

Clarence E. Forbes has joined Jack & Heintz, Inc., as manager of technical employment and training.

Forrest L. Dunbar has been appointed director of industrial relations of the Bendix Products division of Bendix Aviation Corporation announced **George E. Stoll**, corporation vice president and group executive.

Appointment of **James E. Boyce** as commercial sales manager of the California division of Lockheed Aircraft Corporation was announced by **B. C. Menesmith**, vice president and general manager.

George D. Butler has been appointed director of sales at Norden-Ketay Corporation announced **Morris F. Ketay**, president of the company.

Admiral Robert B. Carney, who retired on August 17 as Chief of Naval Operations, will become a consultant to the Westinghouse Electric Corporation.

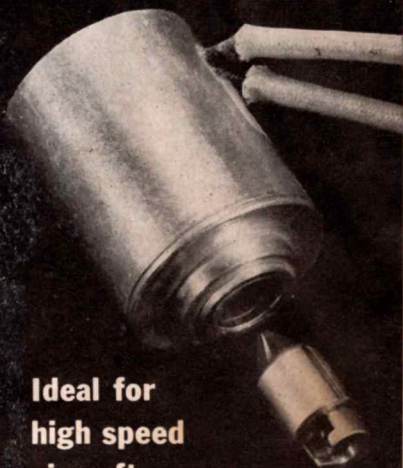
F. C. Weyburne has been appointed general manager of the Skinner division of Bendix Aviation Corporation.

Max Ten Hagen has been named manager of manufacturing, a newly created post, at Solar Aircraft's manufacturing division at the Des Moines plant.

Photographic Acknowledgments

Page 8—Levy-Shipp Photo; pages 22-26—Hiller Helicopters; pages 27-32—Official photographs, U. S. Navy and Flight Refueling, Inc.; pages 38 and 39—Convair; pages 52-54—Martin Company of Baltimore.

500°F AMBIENT SOLENOID



**Ideal for
high speed
aircraft
and missiles**

This solenoid is designed to operate over a temperature range of -67°F to as high as a scorching 600°F, and over a voltage range of 14 to 30 volts d-c. Has a continuous life of 500 hours at 500°F, longer at lower ambients.

Special impregnation makes it unusually compact. Eliminated is the bulky insulation between turns common to other high-temperature units of this type. This impregnation also makes the coil impervious to salt spray and fungus. Design data includes:

Stroke	.156 inches
Coil	
Resistance	14.5 ohms @ -67°F
	21 ohms @ +70°F
	33 ohms @ +500°F
Force	1 pound minimum
Weight	0.7 pound
Operating	
Voltage	14 to 30 d-c

Other J&H high-temperature solenoids include a d-c unit having an .080-inch stroke and 3-pound force... an a-c unit with a .100-inch stroke and 3-pound force. Others can be created to answer your specific requirements. Write Jack & Heintz, Inc., 17631 Broadway, Cleveland 1, Ohio. Export Dept., 13 E. 40th St., New York 16, N. Y.

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Rotomotive AIRCRAFT
EQUIPMENT

Reader Reply No. 22
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TRADE LITERATURE

For further information about Trade Literature reviewed below, make use of our Reader Reply Service. You may obtain copies by circling the appropriate number on the Reader Reply Card on page 69.

Temperature Instrument. 24 pp, catalog describes complete line of Fischer & Porter temperature instruments. Specifications are given for filled thermal systems for indicating, recording, controlling, transmitting, compensating, and programming temperatures from 1400 to 1000 °F. Fischer & Porter. (T-1)

Gear Tester. 4 pp, pamphlet illustrates portable gear tester for speeding production checking. Instrument can be used for rapid check of helical, spur and worm gears and for inspecting incoming shipments of gears. Arch Instrument. (T-2)

Hand Riveter. 2 pp, bulletin 86P covers rotating-impact spinner-riveter hand gun and other models of the all pneumatic Airflex portable series. Airflex. (T-3)

Electric Furnaces. Catalog 521 gives characteristics of general purpose electric furnaces (bench and floor types), high speed electric furnaces, recirculating furnaces, electric ovens, industrial box furnaces and controlled atmosphere tool-room furnaces. Cooley Electric. (T-4)

Welding. Bulletin 332-10 describes Three Phase principle of operation. Use of electronics enables the Sciaky Three Phase machines to draw a balanced current from all three phases of the supply line. The direct current obtained at the welding electrodes offers advantages over the alternating current used on conventional single phase welders. Sciaky Bros., Inc. (T-5)

Furnace Copper Brazing. 4pp, pamphlet describes requirements and procedures for furnace copper brazing in accordance with MIL-B-7883. Superweld Corp. (T-6)

Flame Photometer. 4 pp, folder gives design data on the new Norelco Flame Photometer (Type 12130). North American Philips Co., Inc. (T-7)

Specifying Springs. Illustrated, 8 pp, brochure describes types and classes of precision springs and other related products. Automatic Spring Coiling Company. (T-8)

Serviscope. 6 pp, folder describes industrial applications, outstanding features, advantages and specifications of a multiple signal generator with various signal outputs. Servo Corporation of America. (T-9)

Sintered Metallic Oxides. 6 pp, bulletin No. A-7 describes the properties of Alite sintered metallic oxides, investigates the usefulness of high tem-

perature ceramics in mechanical, chemical and electrical applications. U. S. Stoneware Co. (T-10)

30-KW Induction Heater. Bulletin 85-875 describes the 30-KW induction heater for the metal working industry and the work station housing for all components such as output transformers, capacitors, plumbing for quench and cooling water, contactors and timers. Westinghouse Electric Corp. (T-11)

Automatic Machine Feed Units. 6 pp, illustrated catalog presents diagrams and production layouts for automatic machine feed units. The F. Jos. Lamb Co. (T-12)

Refractory Metals. Bi-monthly brochure discusses applications of the refractory metals tungsten, tantalum, molybdenum and columbium. Fansteel Metallurgy Corp. (T-13)

Method for Holding Parts. 6 pp, data sheet and catalog explains a new expanding method for holding parts while machining, gaging and checking, along with complete engineering drawings and representative applications. Chas. J. Martin & Sons. (T-14)

Type MV High Voltage Resistors. 8 pp, catalog No. G-1a gives comprehensive data on construction, specifications, installations, tolerance, voltage coefficient, temperature coefficient, ratings, insulation, terminations and detailed charts and graphs on type MV high voltage resistors. International Resistance Company. (T-15)

Investment Casting. 10 pp, illustrated brochure outlines steps involved in investment casting and the wide range of intricate parts that may be mass produced by the method. Austenal Laboratories. (T-16)

Alloys and Fluxes. 32 pp, pocket size book condenses into ready reference form the considerable data needed by buyers of specialty alloys and fluxes to help them make choices for their particular applications. All-State Welding Alloys Co., Inc. (T-17)

Indicating Pyrometers. Descriptive bulletin, F 6048-1. These instruments are available in two styles in ranges up to 3600 degrees Fahrenheit. Barber-Colman Company. (T-18)

Silicones. 4 pp, catalog lists silicones in liquid and solid forms; in the broad categories of water repellents; oils and oil emulsions; electrical insulating resins; silicone rubber gum stock and compounds; and silicones that

make anti-spatter, anti-foaming materials. Linde Air Products Company. (T-19)

Capacitors. 10 pp booklet No. GED-2620 describes basic characteristics of specialty capacitors for use in electronic systems. General Electric Company. (T-20)

Capacitors. Descriptive booklet No. GET-2417 gives complete listing of G-E capacitors for the electronic industry with basic applications, ratings, tolerances and temperature ratings. General Electric Company. (T-21)

Capacitors. Technical pamphlet No. GEA-5895C describes complete line of drawn case capacitors for air conditioning equipment with ratings and dimensions. General Electric Co. (T-22)

Capacitors. Explanatory bulletin No. GEA-4996B discusses capacitor networks and methods of determining the suitable unit for each application. General Electric Co. (T-23)

Capacitors. Pamphlet No. GET-2333G provides a complete, revised "spec" on tantalum foil capacitors. General Electric Co. (T-24)

Capacitors. 2 bulletins, Nos. GET-2502 and GET-2513, give specifications for 125 °C. tantalum capacitors, one describing rectangular case units and the other describing cylindrical, double case units. General Electric Co. (T-25)

Capacitors. Illustrated pamphlet No. GEA-6258 gives general information on new lines of tantalum foil capacitors for high temperature applications. General Electric Co. (T-26)

Rubber Products. Illustrated data book describes molded and extruded rubber products. A special section is devoted to the technical specifications and relative properties of natural rubber, Buna S, Buna N, neoprene, Butyl, Thiokol and silicone. Tyer Rubber Co. (T-27)

Spectrometers. 8pp, illustrated, technical bulletin describes direct reading spectrometers featuring the Automatic Servo Monitor. Operation and construction of direct readers also are outlined. Baird Associates, Inc. (T-28)

Electronic Measuring Instrument. 28 pp, booklet describes the proximity meter, a precision electronic instrument that measures without touching the specimen. Robertshaw-Fulton Controls Co. (T-29)

Bearings and Rod-Ends. Revised general catalog No. 55 lists and illustrates a complete line of self aligning spherical bearings and rod ends, including complete engineering data and specifications. Aetna Steel Products Corp. (T-30)

Automation and Systems Engineering. 12 pp, illustrated brochure No. c 901 covers various systems such as data reduction and transmission systems, jet engine tachometer controllers, wind tunnel computer controller

and process connectors. Beckman Instruments, Inc. (T-31)

Unitized Flexi Steel Shelving. 32 pp catalog describes construction and installation features of this product as well as offering detailed information on how to plan a steel shelving layout. The Borroughs Mfg. Co. (T-32)

Figuring Toolplastik Materials. 1 p, chart illustrates amount of tooling plastic needed for a given job. Mixing chart helps determine the amount of material needed for a job. Rezolin, Inc. (T-33)

Inland Story. 40 pp, brochure describes in detail the qualifications, personnel, equipment and facilities available at Inland for a wide range of products and systems testing and evaluation and other testing services available. Inland Testing Laboratories. (T-34)

Radial Ball Bearings. 3-color, 24 pp, catalog describes over 500 different standard radial ball bearings. These bearings are tabulated by bore size ranging from 0.0250-in. to 0.2500-in. Miniature Precision Bearings, Inc. (T-35)

Testing Instruments. Illustrated catalogue describes tensile testers, pressure gauge testers, tachometers, thickness gages, speed indicators, mercury column pressure and vacuum gauges, bursting strength testers, cordage and paper scales. Amthor Testing Instrument Co. (T-36)

Bellows Type Expansion Joints. 36 pp, catalog gives details of construction, specification and general application data for standard Magnilastic expansion joints in various piping systems. Cook Electric Co. (T-37)

Pyrometers. Bulletin F 7259 gives tips on what to do if instrument reading is erratic, instrument temperature curve off, instrument is reading too high or too low. Barber-Colman Co. (T-38)

Instrument Development Service. Illustrated bulletin explains services now available for development of instruments for measuring displacements and surface characteristics, including design, development, building and testing of complete electro-mechanical instrumentation. Micrometrical Development Corp. (T-39)

Activated Alumina. 2 pp, technical data sheet discusses applications for this compound, among which are drying gases such as air, nitrogen, hydrogen, oxygen, carbon dioxide, chlorine, sulphur dioxide, freon, ethylene, butane, by-product coke gas and natural gas as well as many liquids. Reynolds Metals Co. (T-40)

Titanium. 8 pp, booklet gives data about the properties and methods of fabricating titanium. Includes tables giving the mechanical properties of alloyed and unalloyed grades of titanium. E. I. du Pont de Nemours & Co., Inc. (T-41)

Tool Holders. 8 pp, illustrated catalog covers prices and specifications of tool holders for throw-away

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needs no rectifier**

Easy adjustment to desired voltage limits, long life, reliability and simplicity are other features incorporated in this J&H overvoltage relay for aircraft. While designed primarily for J&H a-c control panels, it works equally well on any a-c system or control panel.

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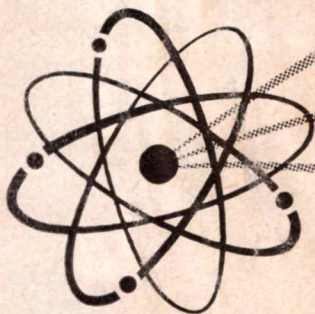
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carbide inserts. Listed are grades, styles and specifications of throw-away insert blanks for use with this product. General Electric Co. (T-42)

Controlled Air Power Devices. 8 pp, bulletin No. ML-3 illustrates the Belwows air motor and its interchangeable valves and describes other standard items such as drill press feeds, vises, hydro-checks, rotary feed and index tables, self contained drilling units, valves and cylinders. The Belwows Company. (T-43)

Stainless Steel. 10 pp, bulletin describes new stainless steel AM 350 designed for the aircraft industry as well as a number of other applications. This alloy can be hardened by elevated temperature treatments, but its best properties are obtained by freezing. Allegheny Ludlum Steel Corp. (T44)

Impregnating Steel with Chromium. 4 pp, reprint explains the Chromalizing process, used to increase the heat, wear and corrosion resistance of ferrous metals by diffusing chromium into the surface at high temperatures. Chromalloy Corp. (T-45)

Surface Alloying Technique. 4 pp, bulletin entitled *Applications of Chromizing* cites 19 typical applications of a relatively new surface alloying technique for increasing the heat, wear and corrosion resistance of ferrous metals by diffusing chromium into the surface at high temperatures. Chromalloy Corp. (T-46)

Industrial Enclosed Switches. 29 pp, catalog No. 83 has been published as an aid to the plant engineer and maintenance man as well as the designer of original equipment and covers a complete line of industrial enclosed switches. Minneapolis-Honeywell Regulator Co. (T-47)

Simplified Drafting. Booklet, 36 pp, presents through the medium of sample drawings of engineered parts and assemblies the 11 illustrated rules, from the use of word descriptions for simple parts to making free hand drawings wherever possible. A straightforward comparison is made between traditional and simplified methods. American Machine & Foundry Company. (T-48)

R-Theta. 2 pp, information release No. 16 describes the R-Theta navigation computer system and its development. This system is designed for use in long range, high speed aircraft and will operate efficiently in short range slower planes as well without need of either ground or airborne transmissions. PSC Applied Research Ltd. (T-49)

Multi-Stage Rocket Program. Bulletin GE-R55A0515, 4 pp, contains a summary of the technical highlights of America's first large multi-stage rocket program, the Bumper Project. Includes short history of program, photographs of a Bumper missile before and during launching and graphs illustrating the acceleration velocity and altitude attained by the Bumper No. 5. General Electric Company. (T-50)

Molded Rubber Parts. 4 pp, bulletin M-1 describes molded rubber parts such as air brake diaphragms, bumpers and snubbers, gaskets of all kinds, spring inserts, oil seals, "O" rings, rubber covered rolls and idlers, regulator diaphragms in a wide range of either natural or synthetic rubber compounds. Quality Rubber and Transmission Co. (T-51)

Aluminum and Magnesium Casting Handbook. A practical guide to the design and specification of aluminum and magnesium sand, permanent mold and die castings. Alloys are described in tables and charts in terms of principal characteristics and uses, specification comparisons, mechanical and physical properties, recommended heat treatment procedures, chemical composition, high temperature tensile properties and creep resistance for specified plastic strains. Rolle Manufacturing Company. (T-52)

Industrial Radiography. 23 pp, illustrated booklet describes the new Kel-Ray projector in which gamma rays do the work of X-rays. This projector is portable. The M. W. Kellogg Co. (T-53)

Precision Tools. Starrett 75th Anniversary Catalog, Bulletin No. 132W, features 85 new tools not heretofore listed plus all other additions to the line of mechanics hand measuring tools and precision instruments, steel tapes, steel rules, dial indicators, dial gages, hacksaws, band saws, band knives, precision ground die and flat stock. The L. S. Starrett Company. (T-54)

Proficorder. 4 pp, bulletin LT16 describes the new Proficorder, a mechanical-electronic instrument that provides a magnified chart record of the profile of internal and external machined and finished surfaces. Micro-metrical Development Corp. (T-55)

Stain Gages. Booklet, 12 pp, includes specifications for all sizes and types of bonded resistance wire strain gages and tells how to select the right gage to meet various conditions of use. Baldwin-Lima-Hamilton Corporation. (T-56)

Hose and Tubing. 15 pp, catalog CC-400 illustrates various types of seamless flexible metal tubing and its uses. The American Brass Co. (T-57)

Titanium Fasteners. 4 pp, pamphlet shows variety of titanium fasteners made by HI TI. These include 12-point external wrenching bolt, six-digit internal hexagon engine bolt, NAS flush head shear bolt, external hexagon head bolt, NAS 144 and MS series internal wrenching bolt, "Unbrako" socket head cap screw, six-digit external hexagon head bolt, 12-point external wrenching nut and "Flexloc" locknut. Standard Pressed Steel. (T-58)

Titanium Bolts. Data sheets on fatigue of titanium shear and tension bolts for aircraft and missile structures, including extensive plots of fatigue tests. HI TI. Standard Pressed Steel. (T-59)

Electronic Equipment. 324 pp, illustrated catalog No. 150 lists over

26,000 items with detailed listings of standard and special purpose electronic tubes, test instruments, voltage stabilizers, transformers, resistors, capacitors, switches, rectifiers, photoelectric components, nuclear instruments, generators and a variety of other electronic equipment and components. Allied Radio Corp. (T-108)

Gages. 8 pp, illustrated brochure describes a variety of standard and special gages and measurement control methods. Shows special and built-up gages, special air gage fixtures and unusual air gage applications. Freeland Gauge Company. (T-109)

Stabilite. 6 pp, illustrated folder describes the new, dimensionally stable, treated and laminated Honduras mahogany that is being used in industry for control of dimensions in original die models and patterns. Aetna Plywood & Veneer Company. (T-110)

Engineering Guide. Revised 1955-1956 Official Resistor Engineering Guide gives data including Jan or Mil equivalent, rated wattage, standard tolerances, temperature rise, temperature coefficient, maximum operating temperature, ohmic values available and dimensions. International Resistance Co. (T-111)

Generator. 2 pp, leaflet form GPM-3 describes a small generator suited for continuous indicating duty in radar instrumentation and similar applications. Included are illustrative draw-

ings and listings. Dalmotor Co. (T-112)

Electronic Humidity Controller. 8 pp, bulletin 2273 describes a new electric hygrometer humidity controller known as the Humistat. This product automatically operates large or small humidifiers, dehumidifiers to maintain humidity control. American Instrument Co., Inc. (T-113)

Molded Rubber Parts. 10 pp, illustrated brochure describes various molded and extruded parts of natural and synthetic rubber and their functions. Tyler Rubber Co. (T-114)

Molecular Bonding. 16 pp, illustrated booklet describes the Al-Fin casting process for the molecular bonding of aluminum and magnesium casting alloys to steel, iron and other metals. Fairchild Engine and Airplane Corp. (T-115)

Metalworking Machine. 4 pp, circular describes the Kidder *Little Blacksmith* No. 55 machine for metalworking shops. Describes attachments available for this machine. J. F. Kidder Mfg. Co. (T-116)

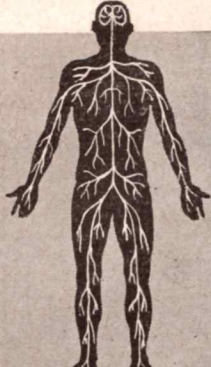
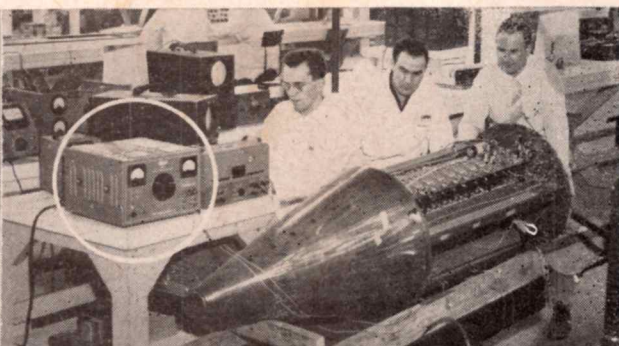
Tubing. 4 pp, bulletin lists available sizes of electric weld steel tubing, which is prepared in standard or odd lengths to meet individual specifications. Nikoh Tube Company. (T-117)

X-Ray. Documentary film explains X-ray diffraction and spectrography.

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Outlines how elements and compounds are identified and measured through studies of the atomic structure. North American Philips Co., Inc. (T-118)

Metallurgy. Chart is designed as a basic guide to ferrous metallurgy and as a reference source for engineers and metallurgists. Represents principal characteristics of steels and shows important working zones such as pre-heating for welding, stress relieving, normalizing, annealing and forging. Tempil Corp. (T-119)

Sliderule. Spec-rule lists specifications, common composition limits, typical physical properties, related physical properties and mechanical properties of major alloys. Howard Foundry Co. (T-120)

Speed Reducers. 40 pp, engineering manual LP No. 3 discusses new Line-O-Power speed reducers with capacities ranging from fractional horsepower to 150 horsepower. Foote Bros. Gear and Machine Corp. (T-121)

Data Repeaters. 5 pp, brochure. Data Repeaters come in three fundamental types, single speed synchro, two speed synchro or potentiometer. Charts and illustrations are included. A. C. Data Repeaters. (T-122)

Sapphires. Price list of synthetic sapphire balls. Available from stock in -- standard sizes from 1/64" to 3/8", including 1 mm. Industrial Tectonics. (T-128)

Motorcompressor. 4 pp, bulletin 3188 describes 125 horsepower, two stage, air cooled, 80-125 psi electric driven air compressor. New size is expected to fulfill the need for a lightweight compressor that can be easily moved from job to job. Ingersoll-Rand. (T-129)

Resins. 2 pp, bulletin 7-222 gives solubility characteristics and typical properties of R-5061 and R-5071 resins. These are essentially solvent free, solid silicone resins that provide a convenient means of formulating special silicone resin solutions. Dow Corning. (T-130)

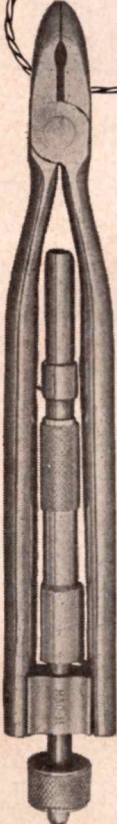
Sheet Lifter. 2 pp, pamphlet gives specifications for 8-cup roll-over vacuum sheet lifter. Metal sheets up to 5 feet wide by 20 feet long can be safely lifted and handled. Littell Machine. (T-131)

Degreaser. 1 p, paper illustrates vapor spray degreasers, available in gas, steam or electrically heated models to suit most installations. Baron Industries. (T-132)

Potentiometers. 2 pp, illustrated paper shows precision ganging potentiometer. Power rating, 8 watts, continuous or brush limited rotation. DeJur. (T-133)

High Precision Parts. Micro-Precision tells of its services and products: system control components for aircraft, servo-mechanisms, hydraulic or pneumatic power-generating components, diesel fuel injection equipment or other parts that require high precision. Micro-Precision Div., Micro-matic Hone Corp. (T-134)

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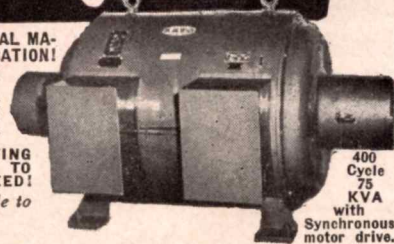
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BOOK REVIEWS

GUIDANCE, Arthur S. Locke, 1955, D. Van Nostrand Co., Inc., Princeton, New Jersey. 729 pp, \$12.50.

This is one of several volumes, collectively entitled *Principles of Guided Missile Design*, which series sets forth the underlying principles of guided missile technology. This volume treats those devices and techniques that are used to guide missiles. Other volumes contain sections called "Operations Research," "Systems Engineering," "Structures and Design Practice," "Aerodynamics," "Propulsion," "Armament," "Launching," and "Range Testing."

The purpose of the series as a whole is to give a basis for instruction to graduate students, professional engineers, and technical officers of

the armed services so that they can become well grounded in the technology of guided missiles.

The "Guidance" section, comprising this volume, was edited by Grayson Merrill, and written by Arthur S. Locke and a group of associates of the Naval Research Laboratory. Material includes emission, transmission and detection of the infrared, measurements of missile motion, detection and information gathering, target considerations and flight paths, airframe, economic considerations, guidance systems, bandwidth studies, and simulation, computation and telemetry.

Circle No. 149 on Reader Reply Card

THE THEORY OF AEROELASTICITY, Y. C. Fung, 1955, John

Wiley & Sons, Inc., New York. 490 pp, \$10.50.

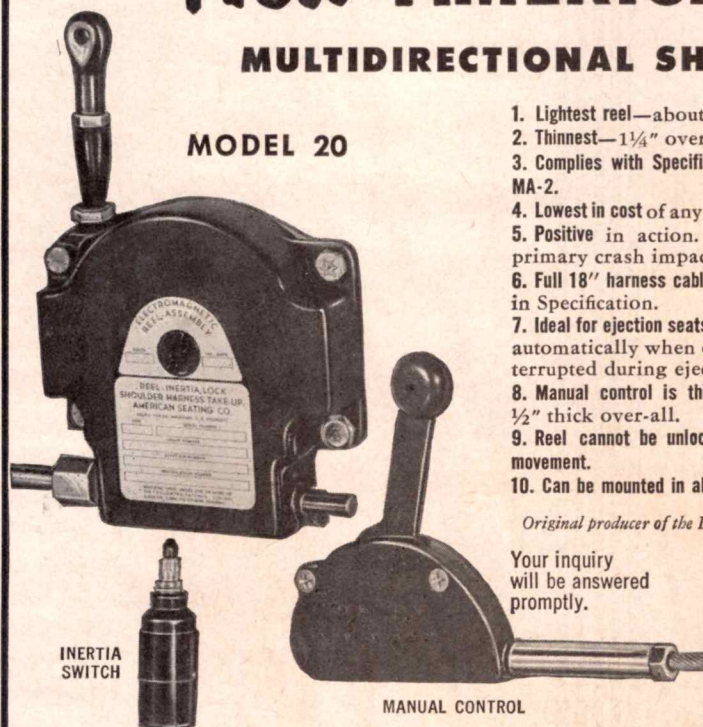
Previous volumes of the Galtcit series (Guggenheim Aeronautical Laboratory, California Institute of Technology) have included two on aerodynamics and two on structural analysis and elasticity. The present work, combining elements from these two fields, stems from a course given at Cal Tech. The book is intended primarily as a textbook, but it should also be useful to designers and flutter engineers, for it gives a composite picture of various aspects of aeroelastic problems. Those engineers having a basic knowledge of aerodynamics and strength of materials should have no difficulty understanding the presentation.

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ABSTRACTS

A. A. Predvoditelev and B. A. Smirnov, **THEORY OF DYNAMIC CREEP**, translated from Russian, NACA TM 1330, September 1955.

An analysis is given of the causes of the increase in creep under varying loads. It is suggested that the increase in creep is due to local rise in temperature over the slip planes, thus facilitating slip. A theory of dynamic creep is proposed, based on the Becker theory of the after effect, which treats the metal as a granular structure and includes a rate factor. Comparison of the theory with experimental results is reserved for a future paper.

Hubert W. Allen and Milton G. Kofskey, **VISUALIZATION STUDY OF SECONDARY FLOWS IN TURBINE ROTOR TIP REGIONS**, NACA TN 3519, September 1955.

A low speed visualization study of turbine rotor tip secondary flows was made. Results include qualitative information on tip-clearance flow, cross-passage flow, and scraping flow, and on a range of rotor speeds for which a transition condition appeared with minimum flow disturbance. Rotor speed required for this transition flow condition depended upon blade configuration, angle of incidence, tip clearance and air-flow rate. Results should aid in extending the study to higher airspeeds.

L. A. Asadourian, **FIRE-RESISTANCE STUDIES OF THE CONVAIR-340 POWER PLANT**, Technical Development Report 266, Civil Aeronautics Administration, Technical Development and Evaluation Center, Indianapolis, Indiana, June 1955.

During the period that fire detection and extinguishing tests of the CV-340 powerplant were in progress, the installation was

also studied with respect to its fire resistance. Air flow and leakage in the power and accessory sections were studied with the aid of a dye introduced into the air stream upwind of the nacelle under simulated flight conditions. The dye technique proved to be a practicable means of detecting loose fits between mating parts. Test fires in the nacelle revealed which materials and components are most likely to fail during a power-plant fire.

G. L. Schott, F. R. Thurston, and P. J. Popcock, **THE ANALYSIS OF THE STRUCTURAL BEHAVIOR OF GUYED ANTENNA MASTS UNDER WIND AND ICE LOADING**, Report MM-238, Division of Mechanical Engineering, National Research Council of Canada, Ottawa, November 24, 1955.

An analytic procedure is described for computing the distribution of bending moment, shear, axial load and deformation in the mast and the loads in the guy wires, for a 3-level, 4-way guyed antenna mast erection subjected to wind load, ice accretion and loads applied by an antenna installation at the head of the mast. The computational procedure is described explicitly with examples and permits the immediate use of normal computational aids.

Part II of the report provides wind tunnel test results on a number of mast designs with simulated ice accretion.

Sharad Patel, Martin Bloom, Burton Erickson, Alexander Chwick and N. J. Hoff, **DEVELOPMENT OF EQUIPMENT AND OF EXPERIMENTAL TECHNIQUES FOR COLUMN CREEP TESTS**, NACA TN 3493, September 1955.

Equipment and procedures developed for testing aluminum-alloy columns subjected to constant loads at elevated temperatures are described. Particular emphasis was put on determination of the influence of initial deviations from straightness on the critical time of the column, that is, the time necessary for the column to buckle when subjected to a constant load.

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The Office National d'Etudes et de Recherches Aéronautiques, 55, Bd Malesherbes, Paris, France, holder of U. S. patents n° 2.677.820, dated may 4, 1954 "System for guiding dirigible craft", n° 2.677.821, dated may 4, 1954 "Blind landing system", n° 2.677.822, dated may 4, 1954 "Point-to-point ultrashort wave radio links" and n° 2.692.986, dated october 26, 1954 "Method and system for guiding dirigible crafts", should like to deal with constructors in the United States through licensing.

Results are presented of tests of a number of 2024-T4 aluminum-alloy columns having large slender ratios.

Ira Smith, Darnley Howard, and Frank Smith, CUMULATIVE FATIGUE DAMAGE OF AXIALLY LOADED ALCLAD 75S-T6 AND ALCLAD 24S-T3 ALUMINUM-ALLOY SHEET, NACA TN 3293, September 1955.

Results are presented of cumulative-fatigue-damage tests made on 607 specimens machined from alclad 75S-T6 aluminum-alloy sheet 0.064 inch thick and 198 specimens of alclad 24S-T3 and alclad 75S-T6 aluminum-alloy sheet 0.032 inch thick. The tests of the 0.064-inch-thick specimens consisted of 35 different loading conditions and the tests of the 0.032-inch material consisted of 13 different loading conditions.

Angelo Miele, OPTIMUM FLIGHT PATHS OF THE TURBOJET AIRCRAFT, translation, NACA TM 1389, September 1955.

The climb of turbojet aircraft is analyzed and discussed including the effects of tangential accelerations. Three flight performances are examined: minimum time of climb, climb with minimum fuel consumption, and steepest climb. Diagrams for quick calculation of the optimum Mach numbers and the effect of acceleration on the rate of climb in tropospheric and stratospheric flight are given.

Robert J. Tapscott and F. B. Gustafson, NOTES ON THE EFFECTS OF EXTREME OPERATING CONDITIONS ON HELICOPTER BLADE FLAPPING, Inst. of Aero Sc. Preprint No. 546, January 1955.

As compared with more conventional types, blade-fuselage clearance for higher-performance, higher-speed helicopters is more difficult both to provide and to estimate or study. Accordingly, as a step towards clarifying the problems involved, this paper endeavors to summarize the present state of knowledge. Some previously unpublished theoretical and experimental studies are utilized in order to illustrate the nature of the effects of several factors on blade motion. Conditions involving severe blade stalling are given primary consideration, and the available evidence concerning the suddenness with which increased flapping may thereby develop is examined.

Theoretical effects of transient control motions during a severe maneuver are illustrated for the case of mass-balanced blades. Some effects of high tip-speed ratios are also discussed, though in less detail.

Jack B. Esgar and Robert R. Ziemer, METHODS FOR RAPID GRAPHICAL EVALUATION OF COOLED OR UNCOOLED TURBOJET AND TURBOPROP ENGINE OR COMPONENT PERFORMANCE (EFFECTS OF VARIABLE AND SPECIFIC HEAT INCLUDED), NACA TN 3335, January 1955.

Curves based on the thermodynamic properties of air and combustion gases for a hydrogen-carbon ratio of 0.167 are presented to relate parameters affecting each engine component. The curves cover a range of flight Mach numbers from 0 to 3.0, compressor pressure ratios from 1 to 30, turbine-inlet temperatures from 1500° to 3000° R, and afterburner temperatures from 2800° to 3500° R. Except for extreme cases, the curves are accurate to at least 3° R in temperature and 1 percent in pressure ratio, fuel-air ratio, and specific thrust. Procedures required for performance evaluation are explained for both uncooled engines with no compressor bleed and for engines utilizing both compressor bleed and turbine cooling. The methods and results of this paper are consistent with current design practice, and the charts here developed are shown by illustrative examples to facilitate the repeated trials and compromises necessary in evolving an economical helicopter design.

Robert Friedman and Edward R. Carlson, A POLAR-COORDINATE SURVEY METHOD FOR DETERMINING JET-ENGINE COMBUSTION-CHAMBER PERFORMANCE, NACA 3566, September 1955.

An automatic polar-coordinate traversing system is described that sweeps a probe through a quarter-annular exhaust duct circumferentially at selected radial positions. With a single combined pressure and temperature probe, temperature and pressure are recorded simultaneously as a function of probe position. The use of these data in calculating temperature and flow profiles, combustion efficiency, and pressure loss is shown.

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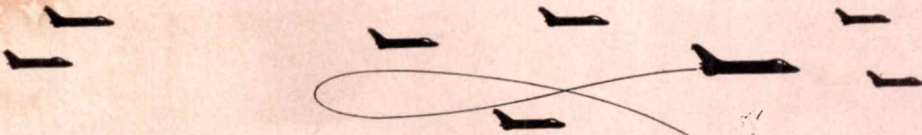
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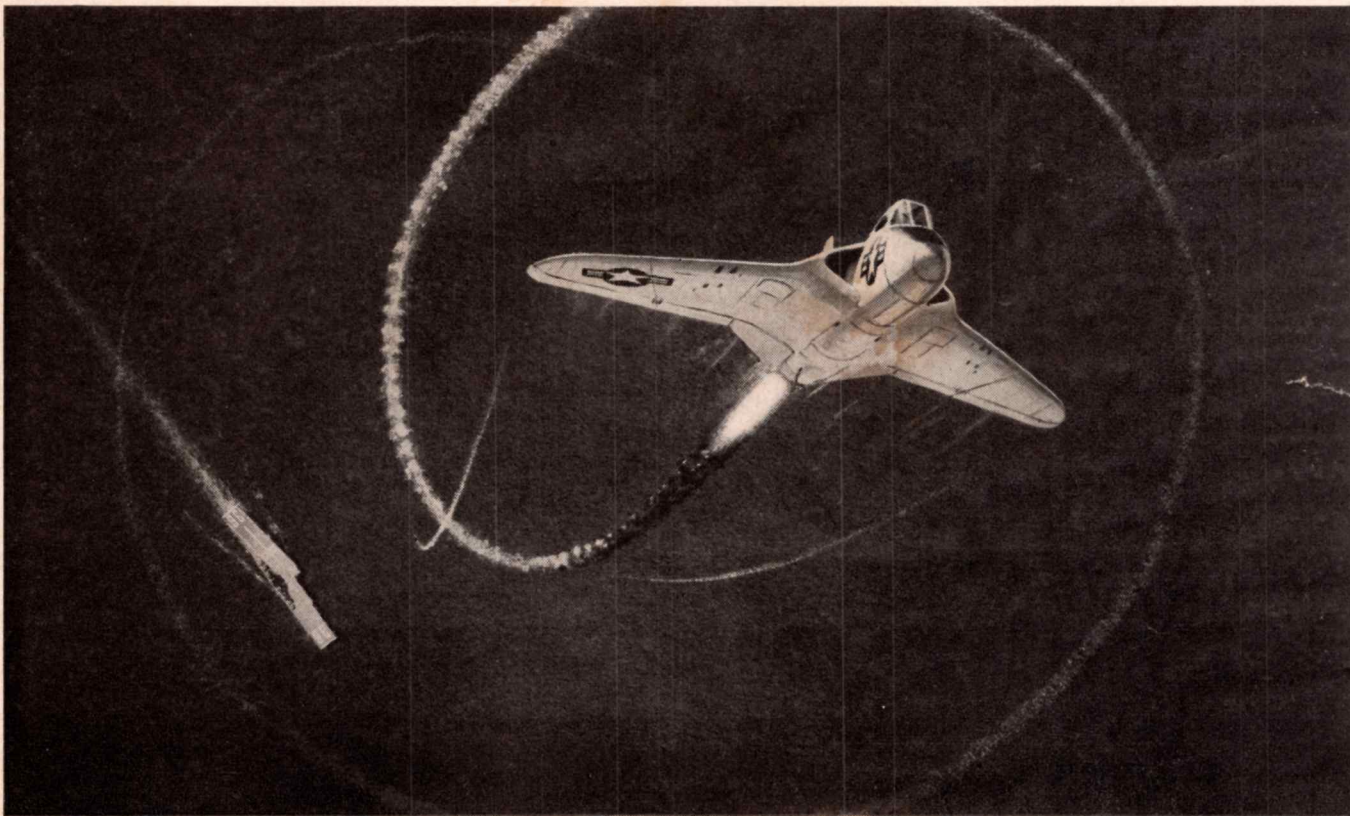
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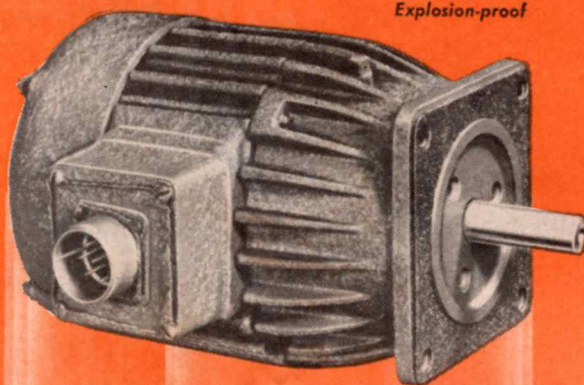
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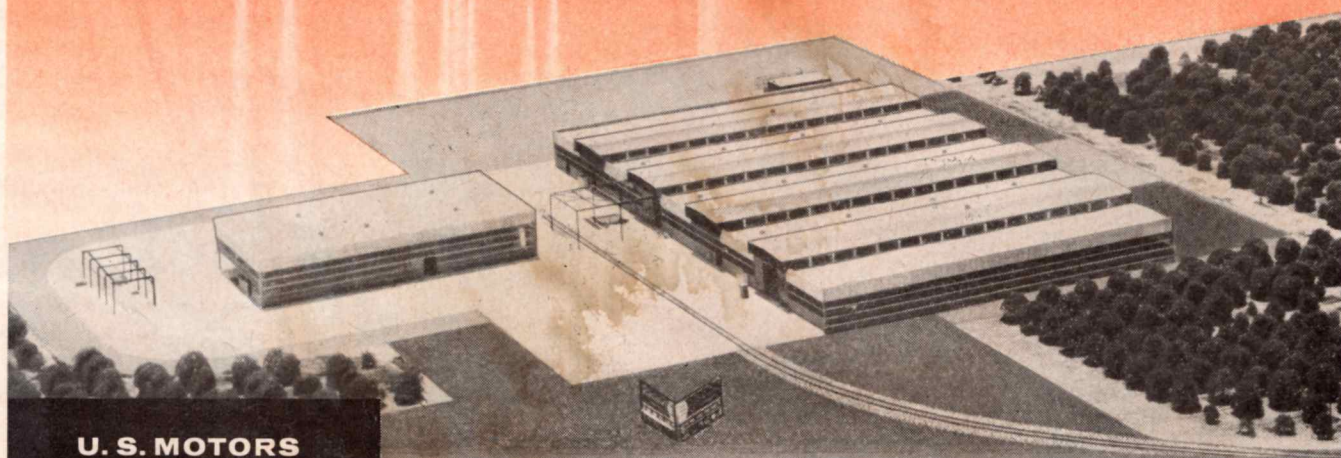


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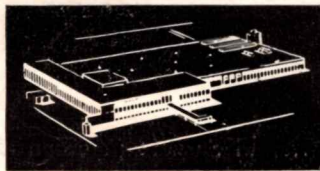
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